



Developing Analytics for Precise Measurement of Hand Dysfunction in Stroke Survivors

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Introduction

Stroke often leads to persistent upper-limb dysfunction, limiting independence and quality of life. Current clinical assessments rely on qualitative observation and fail to capture dynamic grip-load coordination, leaving subtle motor deficits unquantified.

This project evaluates whether fine-grained fingertip force measurements can serve as objective biomarkers of impairment. Using *SenseHand*, a tabletop device that captures grip forces (GF) and load forces (LF) over time, we analyze data from 13 post-stroke patients performing structured grasp-and-lift trials. Each trial involves lifting, holding, and replacing the device using a pinch grip, with varying textures and weights to probe strength, coordination, and sensory interaction.

Objective

Develop a *SenseHand*-based pipeline to quantify post-stroke hand impairment through force analysis

Methods

Task 1: Event Detection

We detect events such as onsets (GFO_n/LFO_n), peak rates (PGFR/PLFR), and lift times (LFL/LFD) while removing incorrectly performed trials by using a 1D temporal convolutional network cascaded with a 1D U-Net.

Task 2: Impairment Analysis

Using the detected events, we calculate clinically-relevant metrics such as pre-load duration, strength, and lift variations. We then use PCA to explain patient variance and serve as a baseline for impairment clustering.

Results

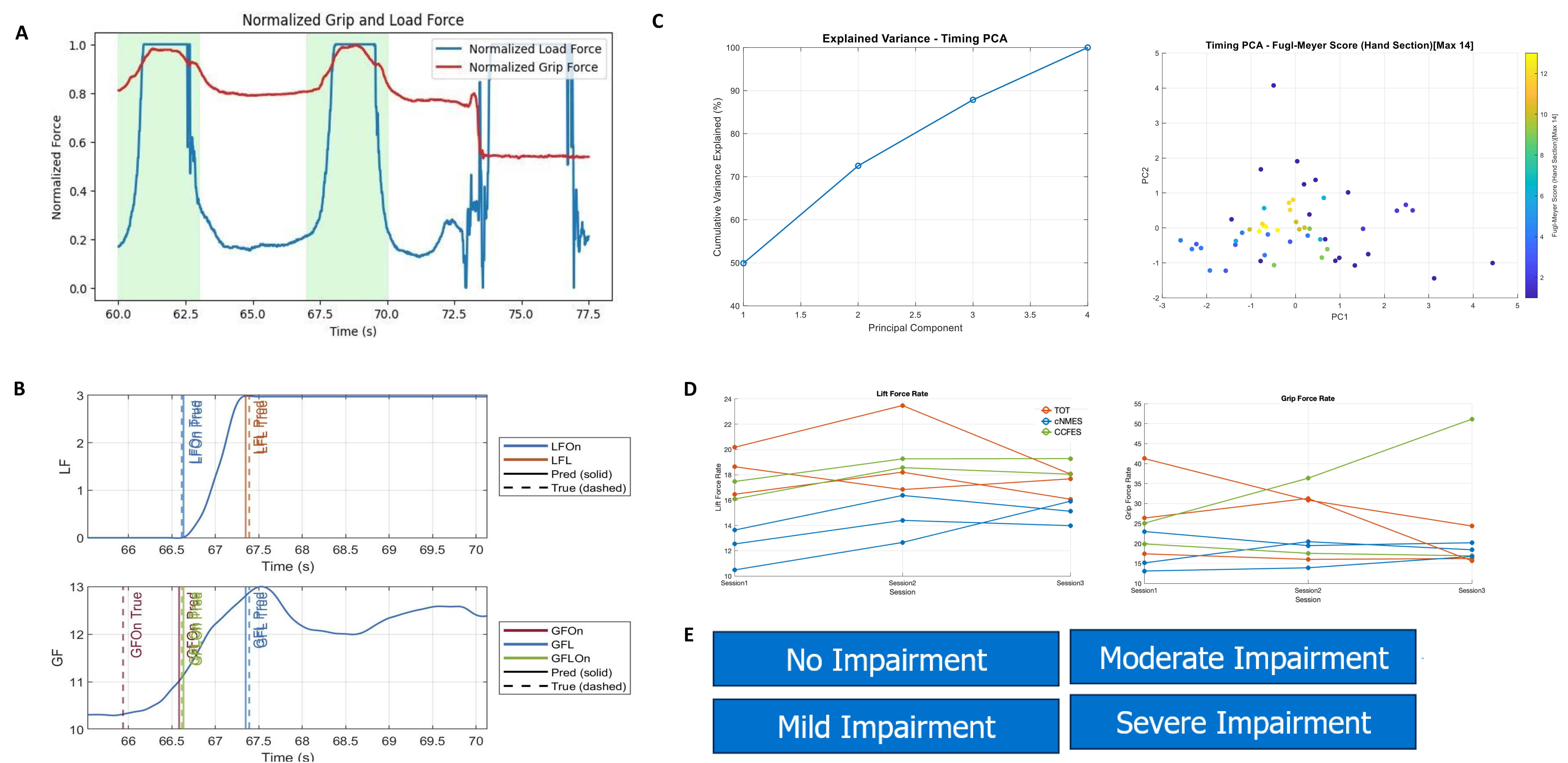


Figure: Results Overview. (A) Processed grip and load force signals following normalization and preprocessing, demonstrating consistency across trials. (B) Event detection results for load force and grip force, showing predicted versus true event timings, with close alignment between model predictions and ground truth. (C) PCA analysis plot for time-related events showing patient clusters based on Fugl-Meyer Assessment. 3 PCs account for 90% variance among patients. (D) Longitudinal analysis of load and grip force rate across sessions, showing recovery trajectories at the patient level across therapy groups. (E) Clinical stratification framework illustrating impairment levels (no, mild, moderate, and severe) used to contextualize force-derived metrics relative to functional outcomes.

Conclusion

- SenseHand enables objective, quantitative assessment of post-stroke hand function by collecting grip and load forces from grasp-and-lift trials across different weight-texture combinations
- Our algorithm complements clinical tools such as the Fugl-Meyer Assessment to create a more complete evaluation of recovery, enable a personalized medicine approach
- In tandem, SenseHand and our pipeline can evaluate different available treatment options such as Task Oriented Therapy and Electrical Stimulation