Wearable Sensing Technologies for Monitoring Real-life Activities in Spinal Cord Injury Individuals

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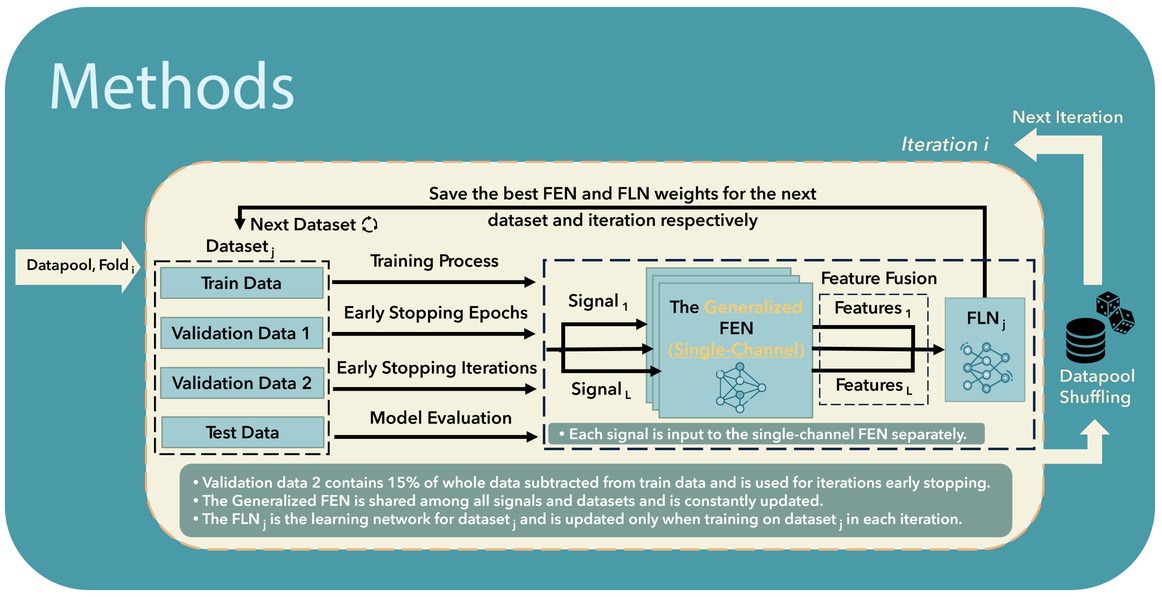
Our wearable sensor system can unobtrusively track vitals, activities of daily living, and behaviors in community setting of individuals with spinal cord injuries.

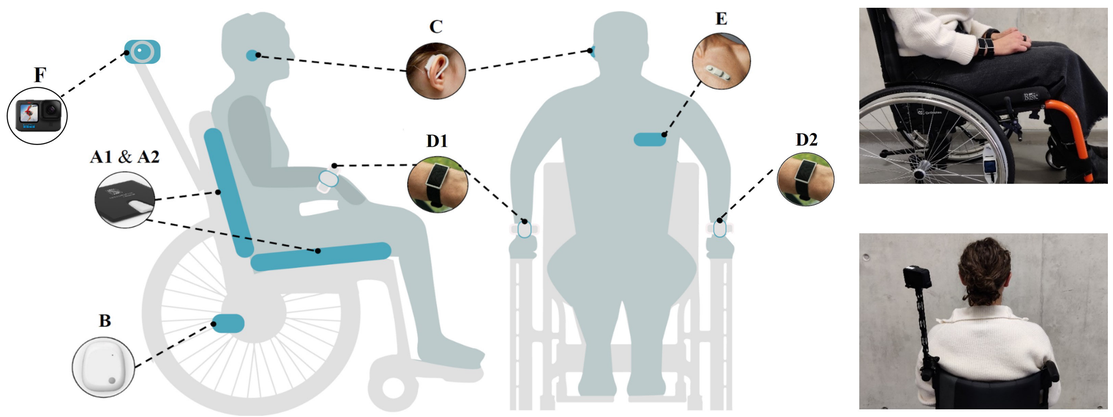
Motivation

- Secondary health conditions impose premature mortality for SCI individuals.
- Monitoring vitals and ADLs can predict the onset of secondary health conditions.

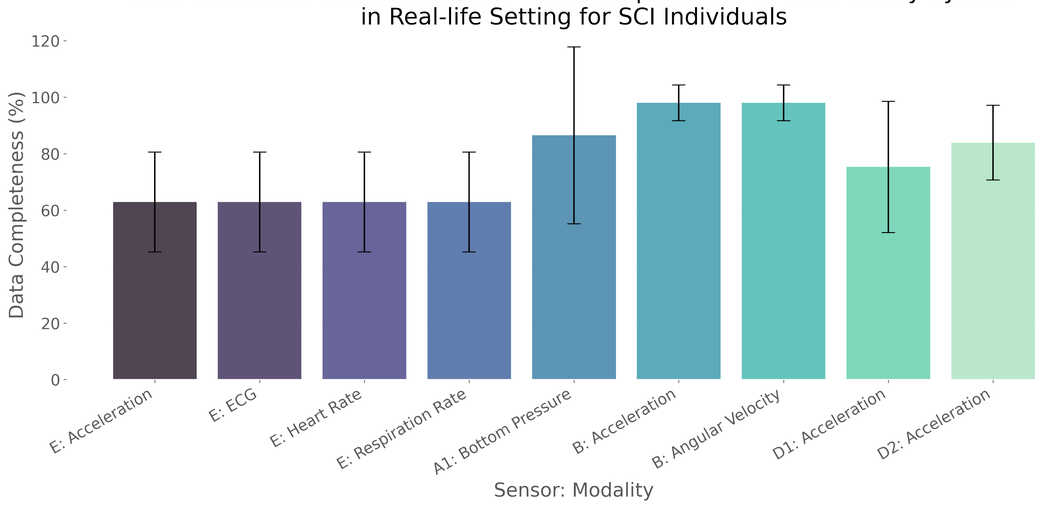
Methods



Data



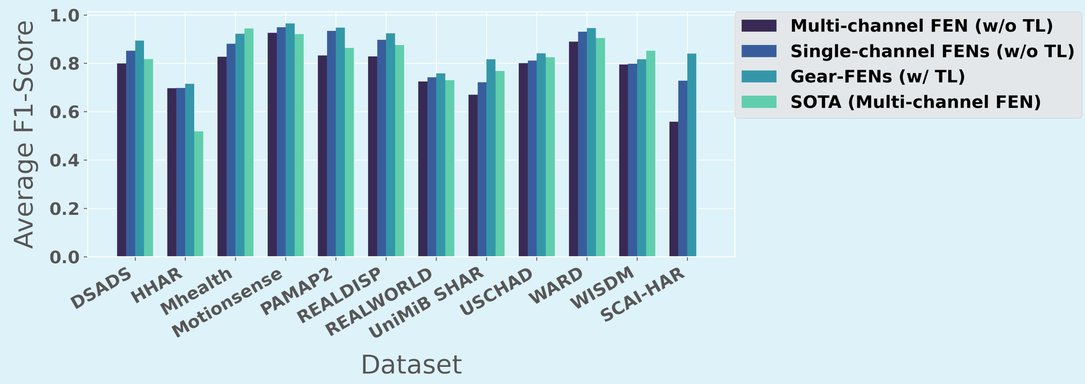
Non-exhaustive Demonstraion of Data Completeness of the Sensory System in Real-life Setting for SCI Individuals



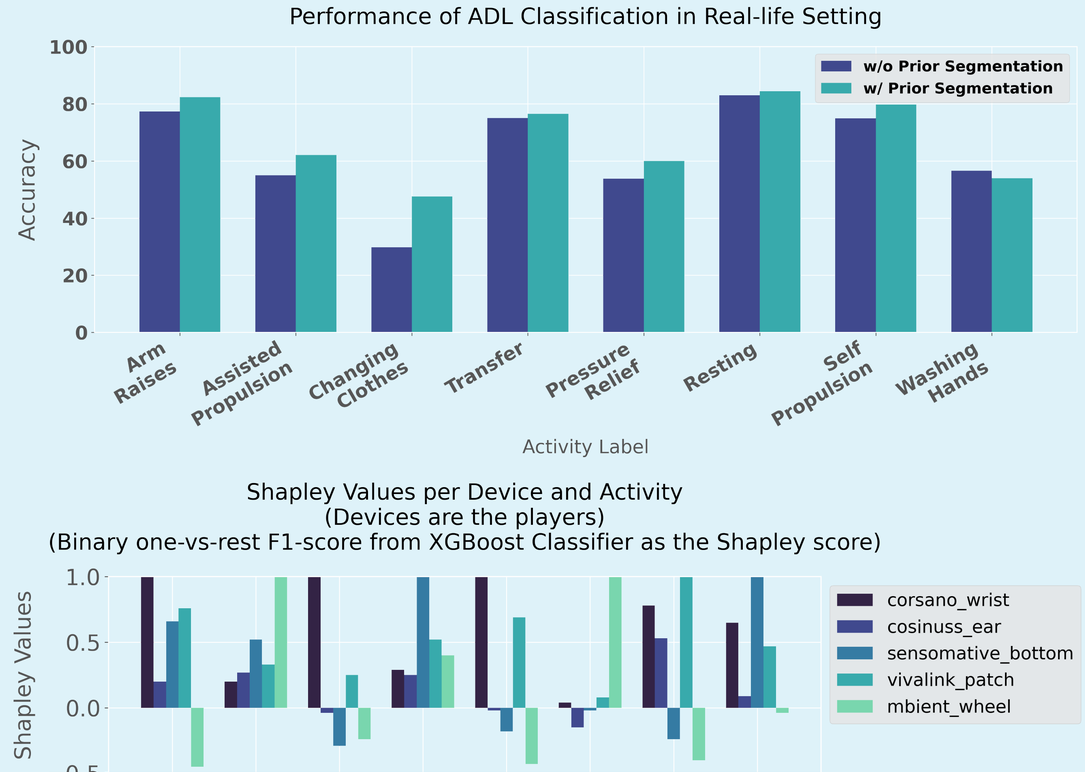
- Analyses were done with 10/15 participants

Results

Average F1-Scores Across Different Feature Extraction Methods (Attention-Based Residual BiLSTM Classification Network)



Performance of ADL Classification in Real-life Setting



Shapley Values per Device and Activity
(Devices are the players)
(Binary one-vs-rest F1-score from XGBoost Classifier as the Shapley score)

$$\varphi_i(v) = \sum_{S \subseteq N \setminus \{i\}} \frac{|S|!(n-|S|-1)!}{n!} \left(v(S \cup \{i\}) - v(S)\right)$$

$\varphi_i(v)$: Represents the Shapley value for device or player i.

$\sum_{S \subseteq N \setminus \{i\}}$: Summation over all subsets S that do not include i.

$\frac{|S|!(n-|S|-1)!}{n!}$: The weight for each subset S, representing the probability of i being added to S.

$v(S \cup \{i\}) - v(S)$: The marginal contribution of device i to the subset S.

Discussion

- Our sensory system can be used for monitoring vitals and ADLs in SCI community setting.
- Our feature extraction model surpassed SOTA on several public datasets.
- Wristbands, Pressure mat (bottom), Chest ECG patch, and the Wheel IMU are the most important sensors for ADL classification.

References

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[3] Zhang, J., Liu, Y., & Yuan, H. (2023). Attention-Based Residual BiLSTM Networks for Human Activity Recognition. In IEEE Access (Vol. 11, pp. 94173–94187). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/access.2023.3310269.

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