Improving Data Efficiency and Accuracy of IMU-Driven Biomechanical Assessment via Self-Supervised Learning

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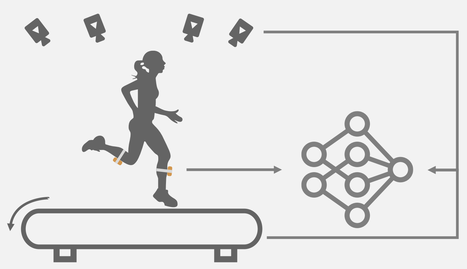
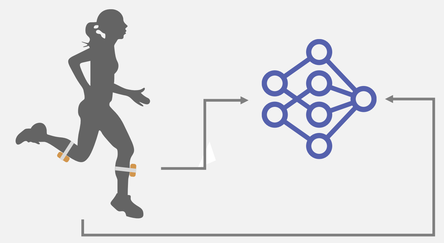
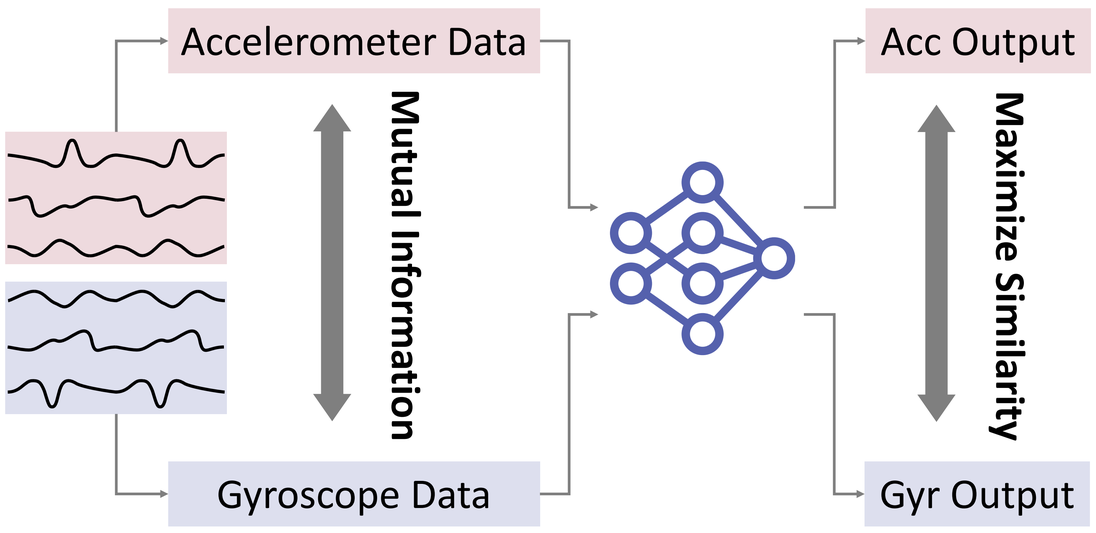
Deep Learning requires large "labeled" datasets with marker (label), force (label), and inertial measurement units (IMUs, input) data for training.



Self-Supervised Learning pre-trains models with large "unlabeled" IMU data. Then, the pre-trained models can be fine-tuned with a smaller amount of "labeled" data.

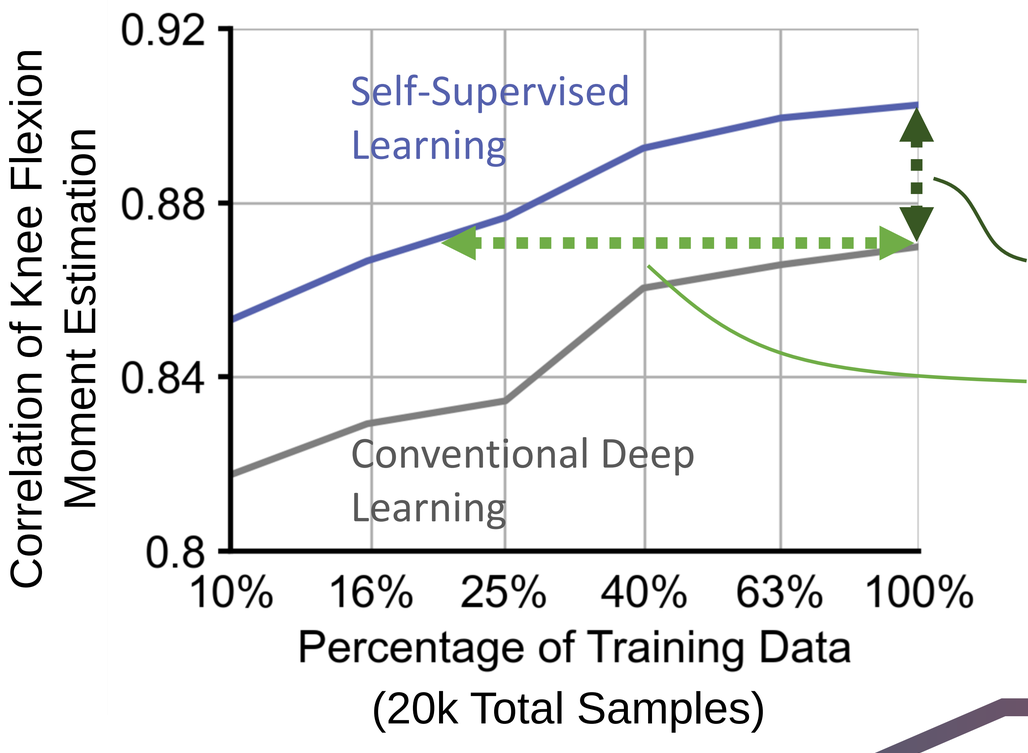




The Pre-training Dataset we used for pre-training is MoVi [1], consisting of 90 subjects performing 21 movements while wearing 17 IMUs.

Self-Supervised Pre-training aims to extract mutual underlying information between accelerometer and gyroscope data from the same window.

Pre-training Procedures. Feed two sources of data into a deep learning model and maximize the similarity of their outputs using Noise Contrastive Estimation (NCE) loss.



Three datasets [2] – [4] were used for evaluation. The self-supervised model was fine-tuned on each dataset to estimate loading rate, ground reaction force, and knee flexion moment.

3% Correlation Improvement

4X Data Efficiency Improvement

(same accuracy with substantially smaller amount of data)

Significance. This approach could unlock newer use cases of IMU-driven assessment where only limited "labeled" data is available.

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https://github.com/TheOne-1/SSL_IMU

Acknowledgement. This work was supported by the Joe and Clara Tsai Foundation through the Wu Tsai Human Performance Alliance.

[1] Ghorbani et al. (2021), *Plos One* 16(6); [2] Tan et al. (2021), *IEEE JBHI* 25(4);
[3] Camargo et al. (2021), *J Biomech* 119; [4] Tan et al. (2022), *IEEE TII* 19(2).