FineRehab: A Multi-modality and Multi-task Dataset for Rehabilitation Analysis

Jianwei Li [*†1], Jun Xue [*1], Rui Cao [1], Xiaoxia Du [2], Siyu Mo [1], Kehao Ran [1], Zeyan Zhang [2]

[1]School of Sports Engineering, Beijing Sport University, China [2]Department of Neurorehabilitation, Rehabilitation Research Center, China

CVPR SEATTLE, WA JUNE 17-21, 2024

1.Overview

Motivation

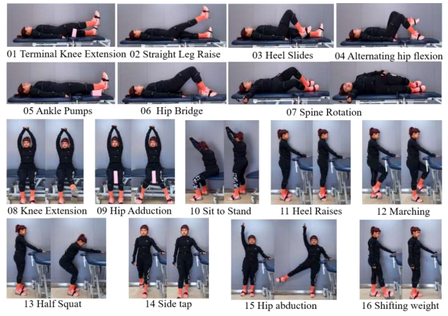
- There is a high demand for remote rehabilitation monitoring that can provide repeatable, quantitative and interpretable results of Action Quality Assessment (AQA).
- The existing rehabilitation datasets in AQA are not rich enough because of single-modality data and coarse-grained annotations. Also, related datasets have limited capabilities in generalizing across different populations.

Main contributions

- We propose a multi-modality and multi-task dataset for rehabilitation movement analysis.
- Independently spatial and temporal categories are proposed to further explore fine-grained action recognition and AQA.
- We provide comparative experimental comparisons between the normal population and patients on FineRehab dataset.

2.FineRehab Dataset

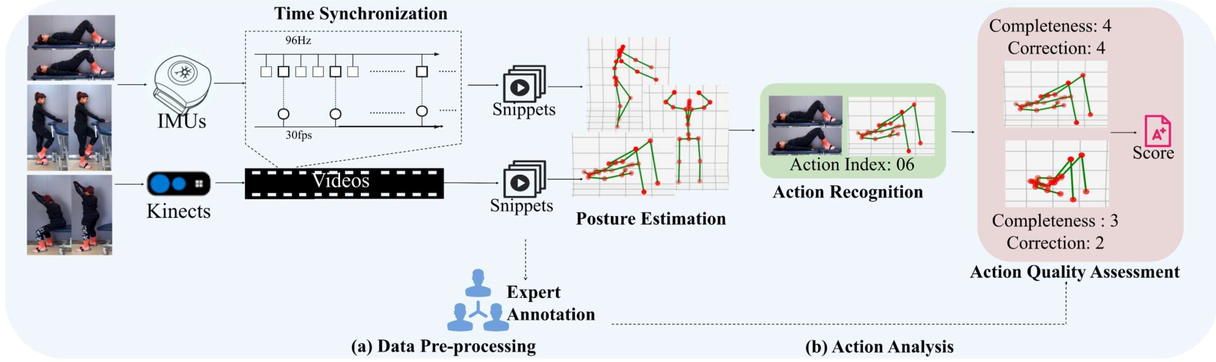
The dataset was collected by 2 Kinect Azure cameras and 17 IMUs to capture the kinematic data of 16 rehabilitation movements. 50 volunteers (30 musculoskeletal disorders patients and 20 healthy individuals) participated in this study. The data was processed through calibration, segmentation, time synchronization and posture estimation. Then, 4,215 snippets was annotated by 3 experts. FineRehab includes following data:



- Subject information
- Calibration information
- RGB images (front/side)
- Depth images (front/side)
- Skeleton from IMUs and posture estimation
- Expert annotations of each joint's performance among 3 AQA dimensions
  - **Completeness**
  - **Correction**
  - **Smoothness**

3.Method

The pipeline of our proposed rehabilitation exercise analysis method.



4.Experimental Results

Action Recognition

Top-1 accuracy cross-subjects and data augmentation

Model	Data	Aug	Best Epoch	Accuracy
ST-GCN	H[1]		174	84.35%
ST-GCN	H[1]	✓[4]	119	**90.34%**
ST-GCN	P[2]		124	77.61%
ST-GCN	P[2]	✓[4]	94	75.51%
ST-GCN	H&P[3]		139	87.94%
ST-GCN	H&P[3]	✓[4]	94	87.44%

[1] H represents healthy participants.
[2] P represents patients.
[3] H&P refers to all participants.
[4] "✓" indicates that the skeletal data was augmented.

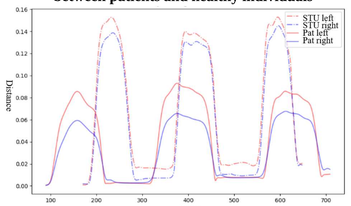
Top-1 accuracy cross-models, cross-skeletons and cross-subjects

Models	Data	Estimated	Best Epoch	Accuracy
ST-GCN	H[1]		174	84.35%
ST-GCN	H[1]	✓[4]	74	77.07%
ST-GCN	P[2]		124	77.61%
ST-GCN	P[2]	✓[4]	59	52.32%
ST-GCN	H&P[3]		139	**87.94%**
ST-GCN	H&P[3]	✓[4]	79	80.02%
UNIK	H[1]		35	**92.63%**
UNIK	H[1]	✓[4]	37	84.58%
UNIK	P[2]		63	76.07%
UNIK	P[2]	✓[4]	68	59.23%
UNIK	H&P[3]		54	86.49%
UNIK	H&P[3]	✓[4]	34	80.33%

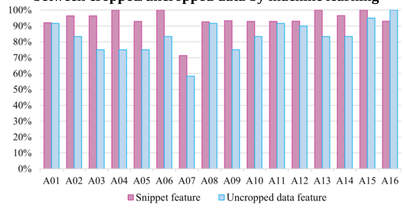
[4] "✓" indicates that the skeletal data was estimated using MediaPipe, while the absence of "✓" indicates that the skeletal data was directly collected via IMUs.

Action Quality Assessment

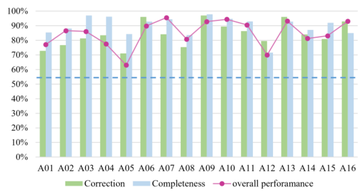
Differences of kinetics features after DTW between patients and healthy individuals



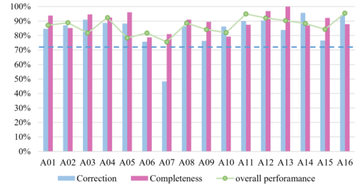
Accuracies in distinguishing normal/abnormal movements between cropped/uncropped data by machine learning



AQA accuracies of 16 movements for each dimension by ST-GCN



AQA accuracies of 16 movements for each dimension by UNIK



Each column presents the AQA accuracy for EACH movements, while the blue lines represents the overall performance accuracy training with 16 kinds of movement data (lower than 16 movements independent training).

5.Conclusions

In this study, we introduce the FineRehab dataset, a multimodality and multi-task dataset designed for fine-grained rehabilitation exercise analysis. We have conducted exhaustive action recognition and multi-dimensional action quality assessment on our dataset using both traditional and deep learning methods, and offer insights into differences between healthy individuals and patients, validating our dataset's utility for personalized rehabilitation.

Future works

- Improve recognition accuracy for supine movement relatively lower than standing and sitting pose, which may caused by inferior posture estimation inputs.
- Implement adaptive data augmentation for specific population and movement.
- Design a network to efficiently assess the quality of diverse types movements.

Acknowledgements

This work is partially supported by the National Key R&D Program of China (No.2022YFC3600300 and 2022YFC3600305), Beijing Higher Education Undergraduate Teaching Reform and Innovation Project (No.202310043003), and the Fundamental Research Funds for Central Universities (No.2021TD006 and 2022YB007).

Contact us

Email: jianwei@bsu.edu.cn;
jxue@bsu.edu.cn;

FineRehab Dataset will be available at: https://bsu3dvlab.github.io/FineRehab.