Breakout Session 2: Track A

Development of Deep Learning-Based Kinematic Data Acquisition

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The Development of Deep Learning-based Kinematic Data Acquisition

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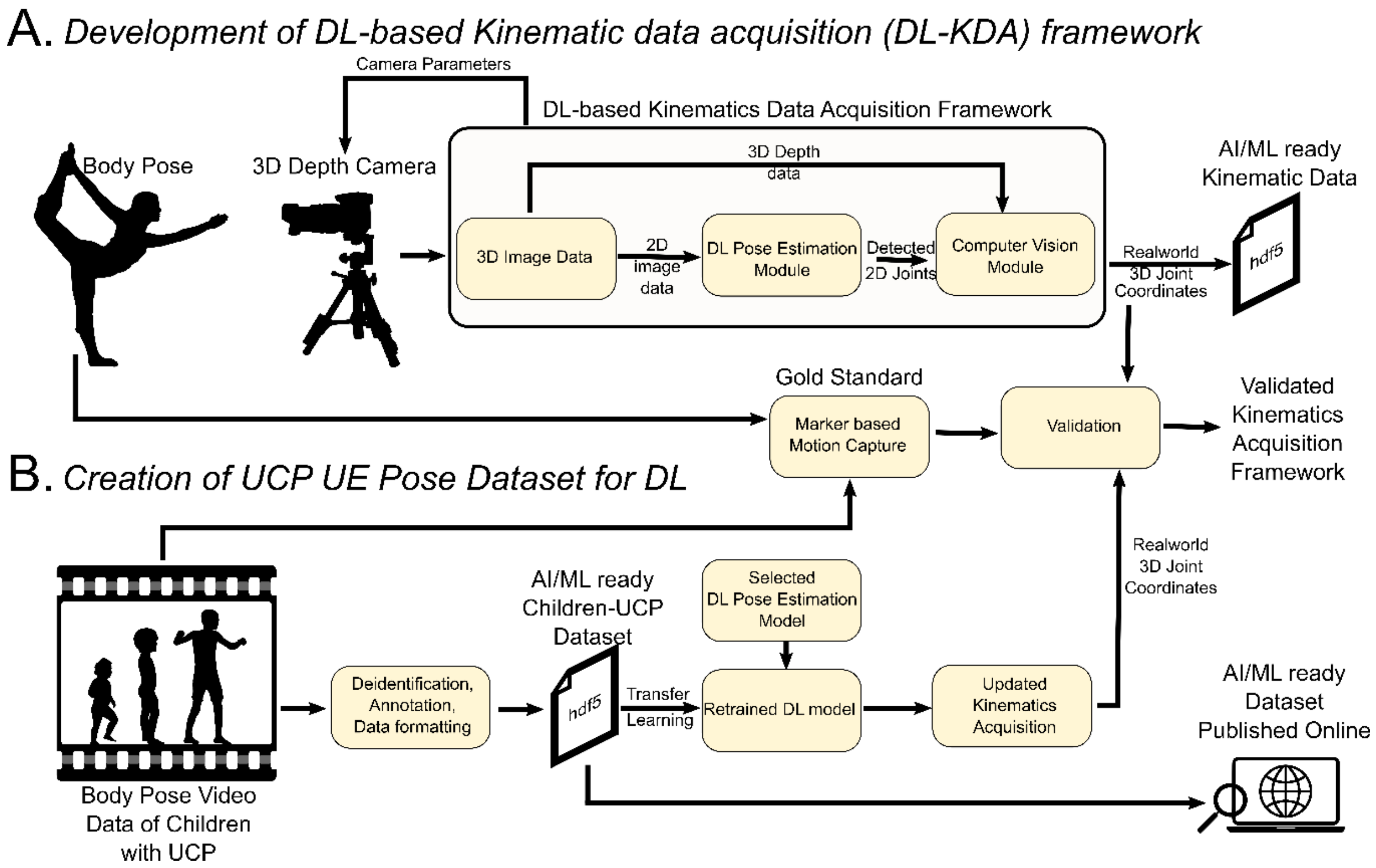
Burke Neurological Institute / Brain and Mind Research Institute- Weill Cornell Medicine

Project Summary

- Determine how to optimally target transcranial direct current stimulation (tDCS) to enhance upper extremity (UE) efficacy training in children with unilateral cerebral palsy (UCP).
- Most existing hand function assessments miss finer details on movement that is reflected in kinematics.
- Critical information from changes in movement kinematics is ignored
- Can help optimize interventions
- Until recently, kinematic data extraction has been expensive and/or unreliable.

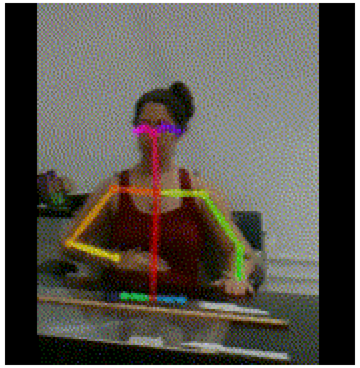
Supplement Project Goals

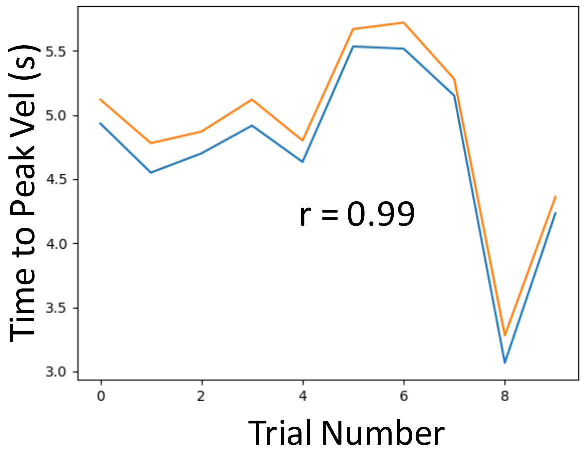


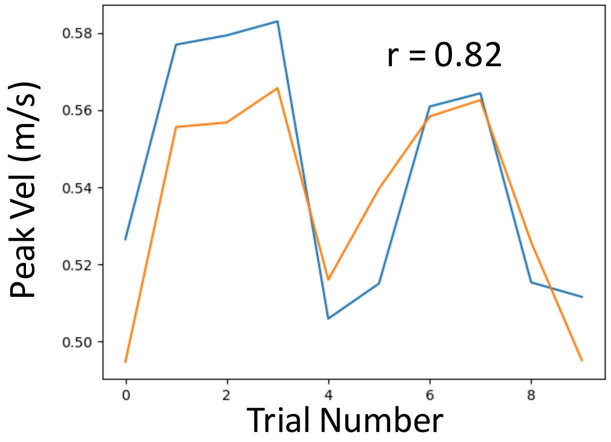
Validation : Wrist movement during reaching tasks

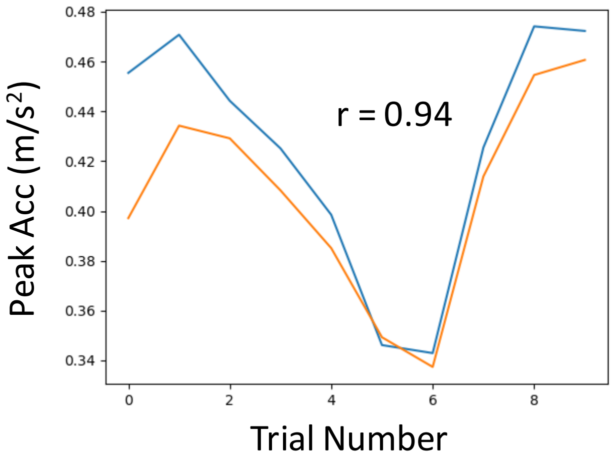
3D Camera + PEACK

VICON motion capture + PEACK









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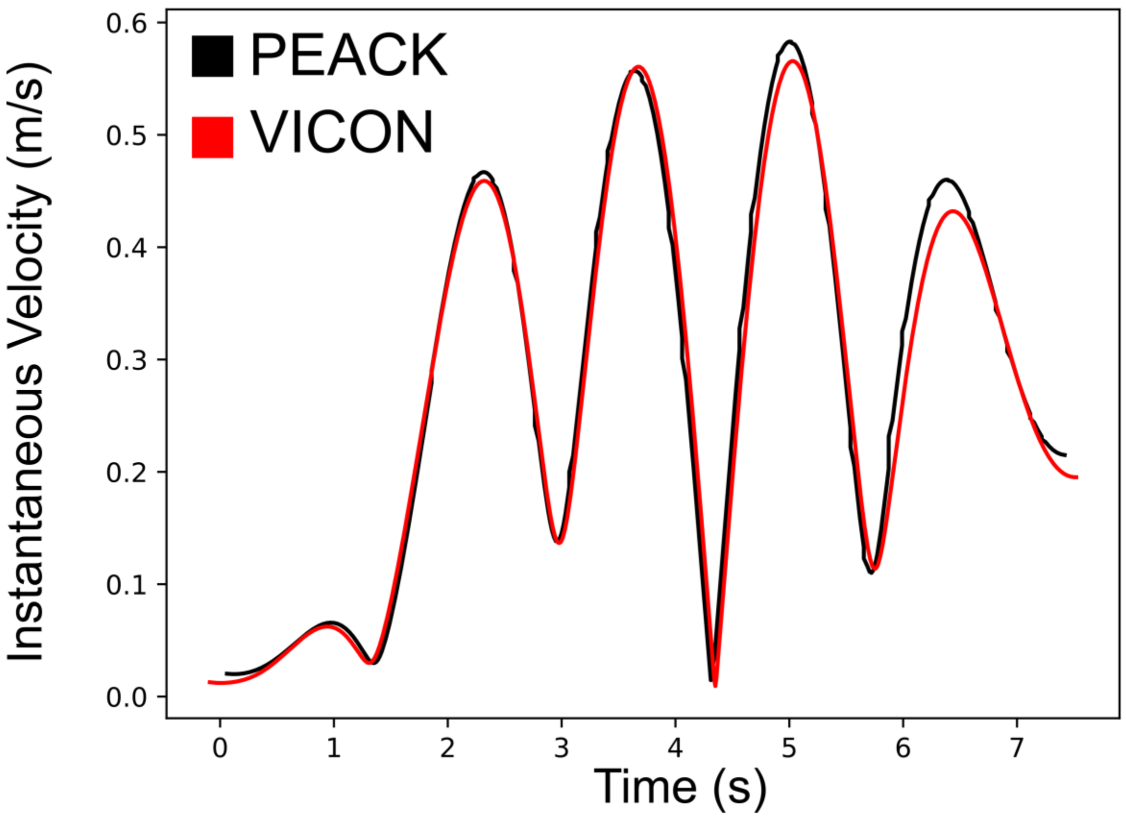
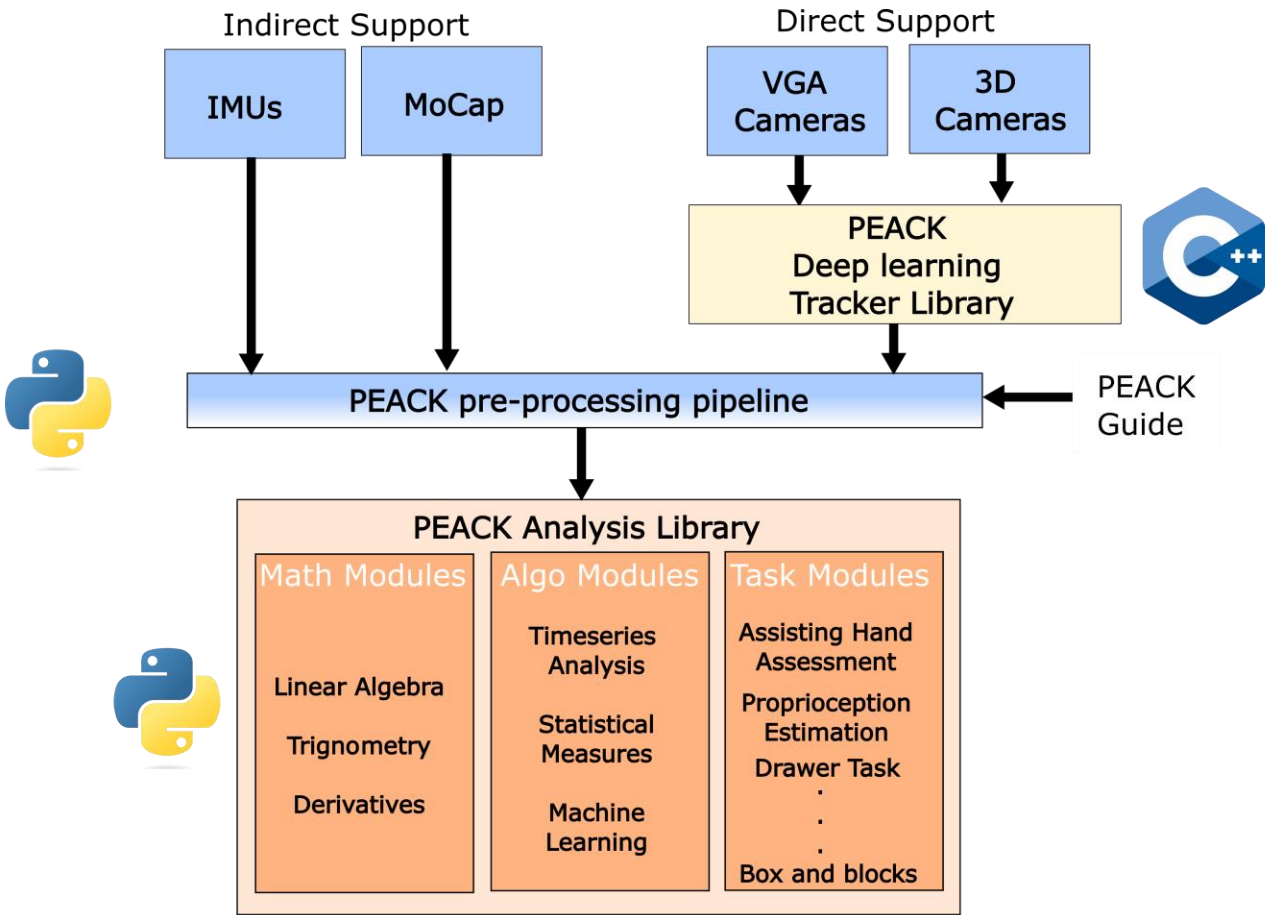


Dataset construction

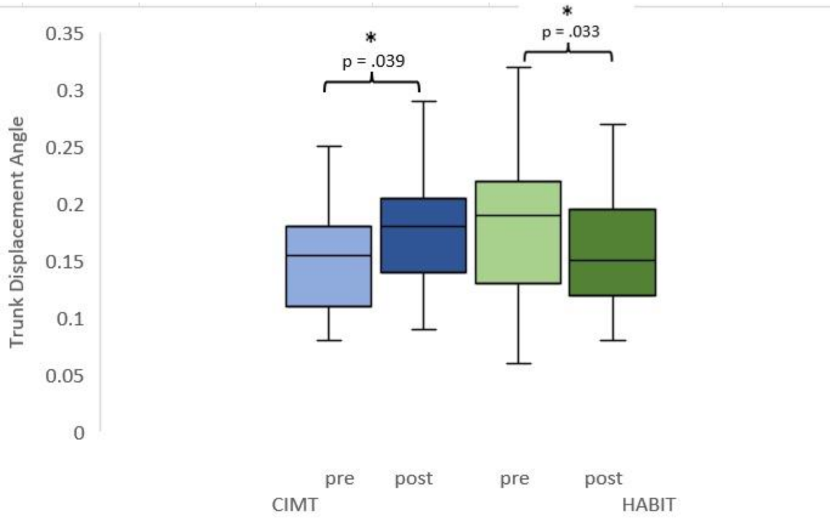
- Retrospectively obtained and analyzed a total of 135,000 images of 50 children with cerebral palsy performing upper limb movement from a previous cohort (2015-2018).
- Obtained and analyzed a total of 50,000 images of 21 children with cerebral palsy during static poses with upper limbs.
- Obtained and analyzed a total of 72,000 images of 10 children with cerebral palsy during unimanual reaching-grasping task.

Current PEACK framework



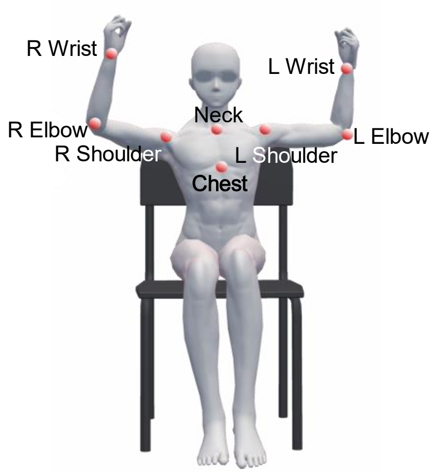
https://github.com/shivak7/PEACK

Using PEACK to study Trunk movement during Assisting Hand Assessment

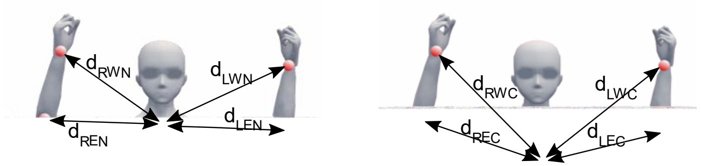


Using PEACK for studying proprioceptive position sense

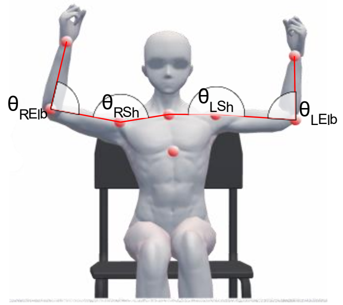
A) Measured Joints



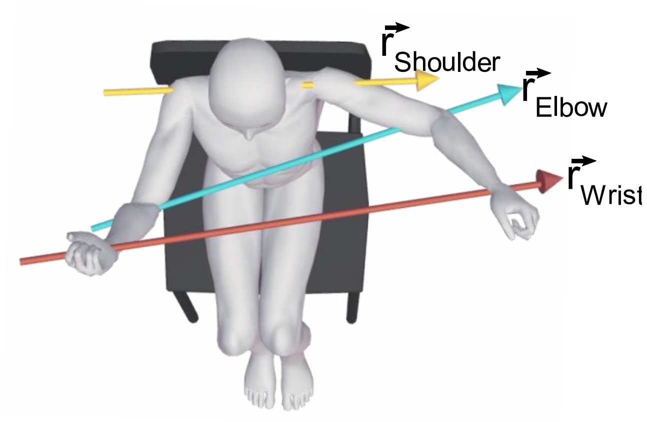
B) Distance Symmetry



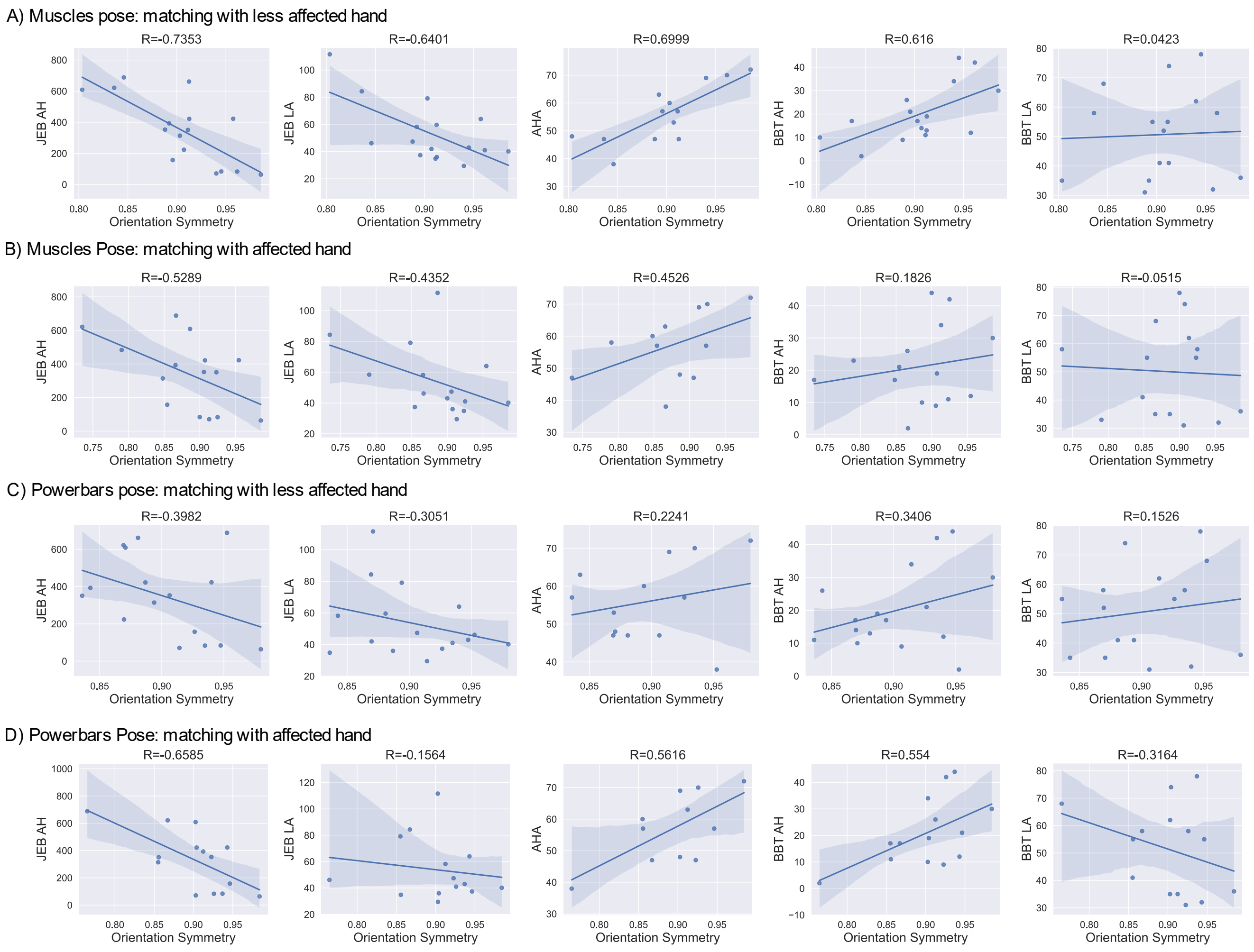
C) Angle Symmetry



D) Orientation Symmetry



Using PEACK for studying proprioceptive position sense



Challenges

1. General noise in marker-less kinematic data

- Careful filtering of data to adjust for body tracking artifacts introduced by the Deep Learning tracker.
- High pass filtering (5^{th} order, 5Hz cut off) followed by median filtering with a window between 0.1 to 1 times the sample period.
- Filter parameters should be adjusted depending on the task.

2. Noise from additional individuals appearing in background

- Unique identification of each individual is still a challenging problem in DL trackers.
- Implemented a semi-supervised heuristic method of tracking a single person.

3. Nature of typical tasks has view of lower limbs missing in recordings and kinematics

- Make initial dataset focus specifically on upper limbs.
- Add views of entire individual during assessments.

Challenges

4. Increase dataset size of annotated images of children with cerebral palsy.

- Use semi-supervised labeling methods.
- Include image data from other studies (collaborators) of children with cerebral palsy.

5. Validating hand movement kinematics in upper limbs using marker based mocap.

- Participants are conscious of markers and adhesive contact with the skin.
- Hand movements are more unnatural.
- Use smaller markers and/or adhesives which can stretch with skin.

Future Work

- Collect full body movement videos from children with cerebral palsy.
- Retrain DL body tracker libraries with updated dataset.
- Implement multi-camera support within the PEACK framework.
- Add DL depth estimation support to try extracting 3D kinematics from 2D videos.
- Add DL Frame interpolation support to improve video quality and decrease error in extracted kinematics.
- Expand PEACK support to other available modes of body tracking.

Thank you!