UNIVERSITÀ DEGLI STUDI DI BRESCIA

Laboratorio di Misure Meccaniche e Termiche

DEEP LEARNING FOR GESTURE RECOGNITION IN GYM TRAINING PERFORMED BY A VISION-BASED AUGMENTED REALITY SMART MIRROR

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Can a low-cost vision system evaluate in-house gym training kinematics?

Measurement System:

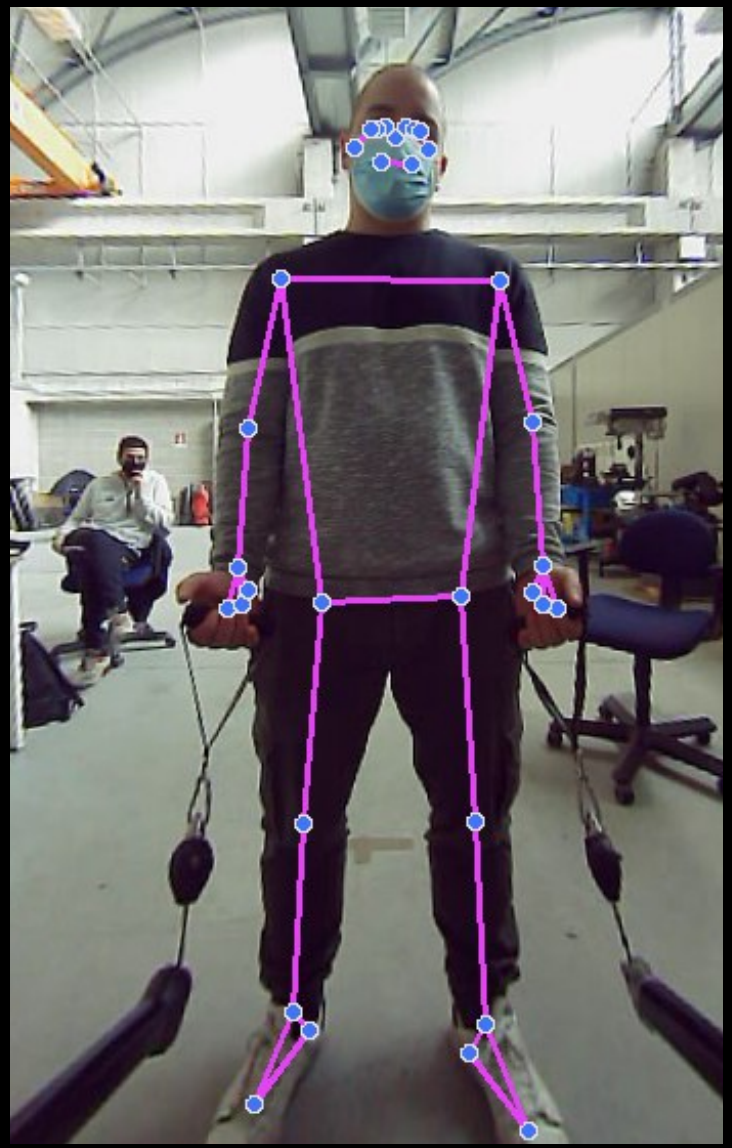
- Skeleton (Pose)

camera
+
machine learning

Validation:

- Accurate?
- Repeatable?

athlete
+
reference mocap



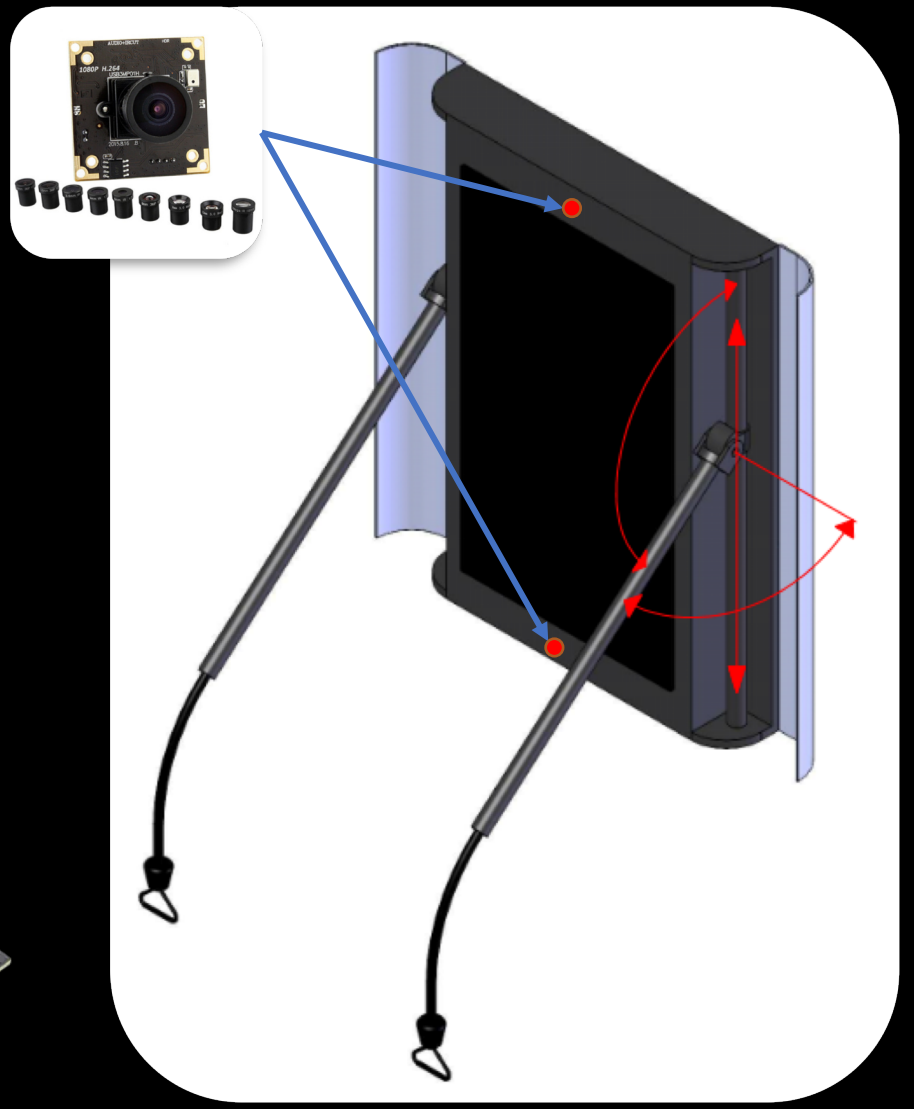
Measurement system

OUTSIDE

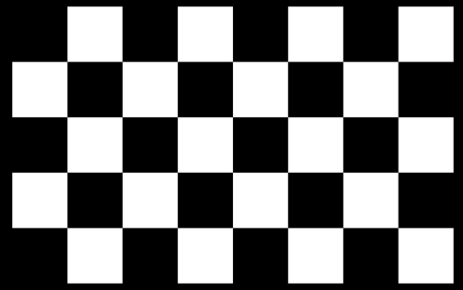
- Smart gym with dynamic weight and digital mirror for exercise evaluation

INSIDE

- Nvidia GPU core with AI application and two fisheye cameras



Software used



calibration → accuracy

MediaPipe

Prediction → real time

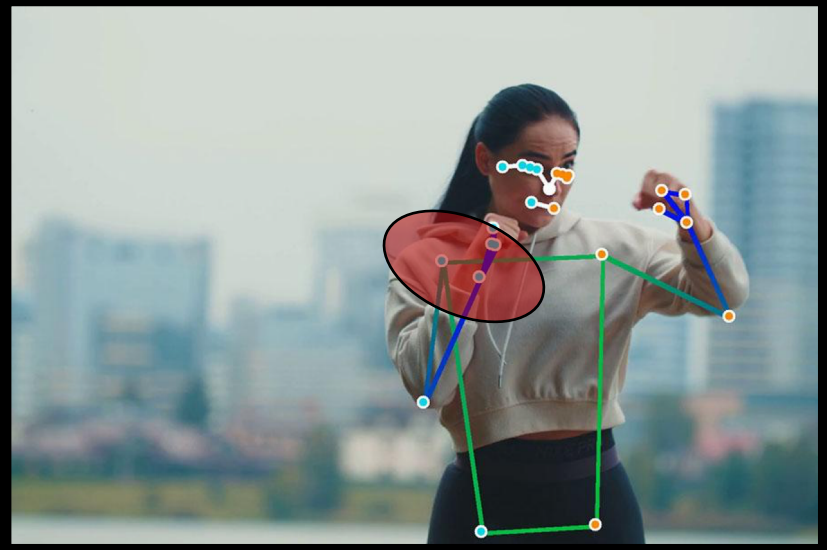
skeletonization → Keypoints data

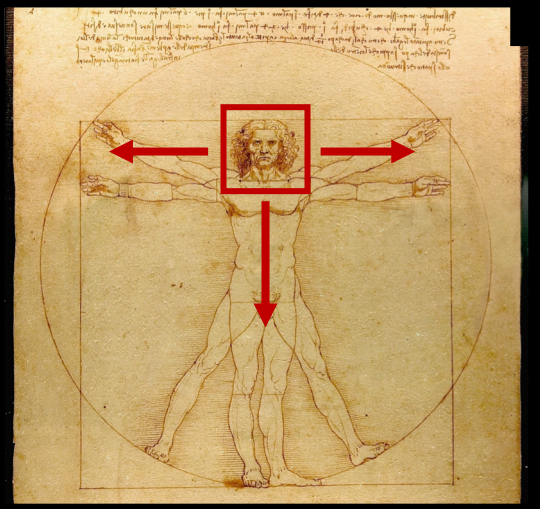
Kinematics data

- Open-source predictive deep learning algorithm for real-time human joints estimation
- Fisheye camera calibration to correct distortions with OpenCV

Drawbacks and limitations

- Residual distortion from the calibration
- Occluded and overlapping joints
- Face detection approach
- Mediapipe training accuracy (PCK@0.2)





Evaluation protocol

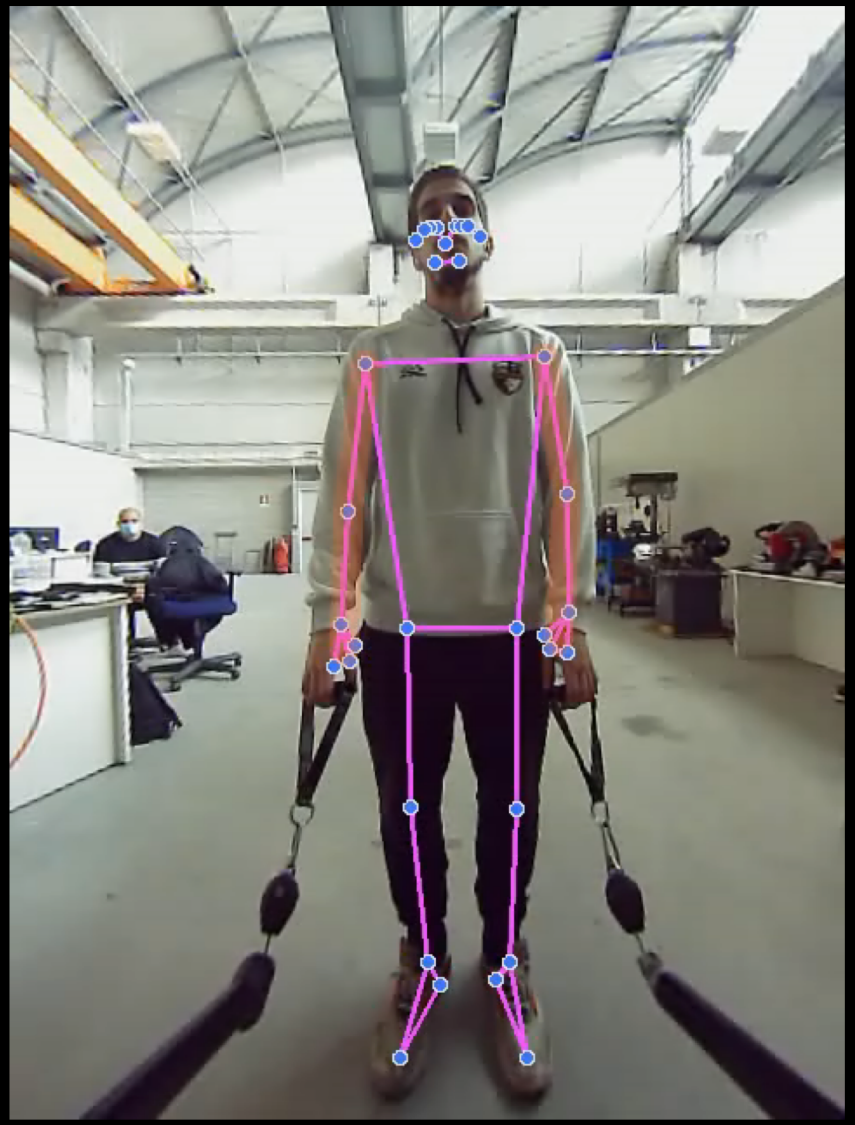
- 3 able-bodied subjects
- *biceps curl* exercise
- 3 times with at least 5 repetitions

Evaluated metric : α (elbow angle)

- Peak value per cycle
- Time history

Ground-truth: BTS MCsys

- 0.3 Mpx resolution at 140 FPS
- ±0.2 mm in 2x2x2 m volume



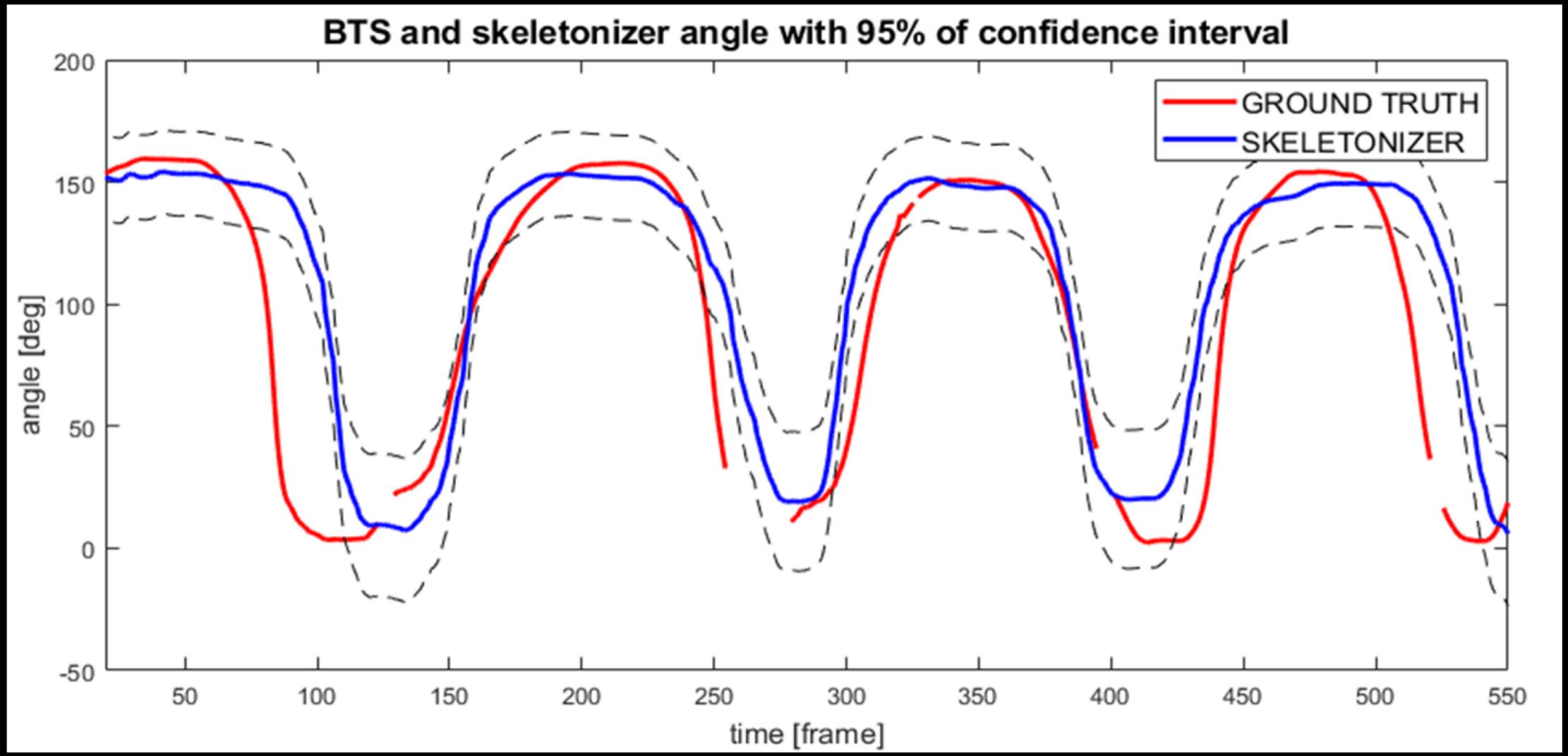
Results

Evaluation variable: elbow angle

elbow angle projected on the mirror plane

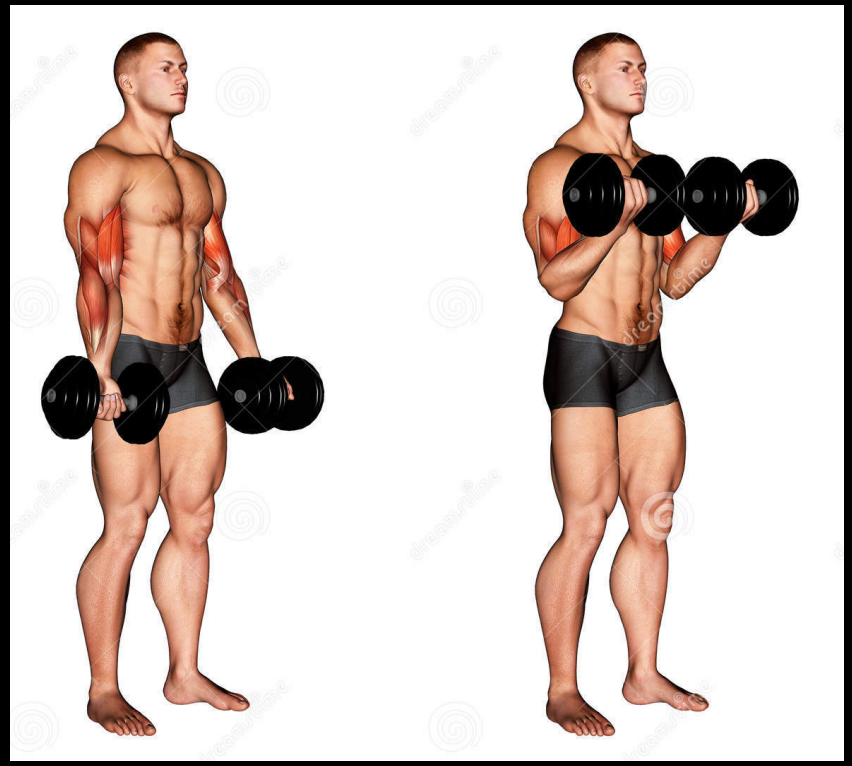
- Evaluated metrics:

- *RMSE* of the Skeletonizer w.r.t. ground truth for **accuracy**.
- *Std. dev.* of the peaks for intra e inter-subject **repeatability**



Elbow angle time evolution with uncertanty during *biceps curl* exercise

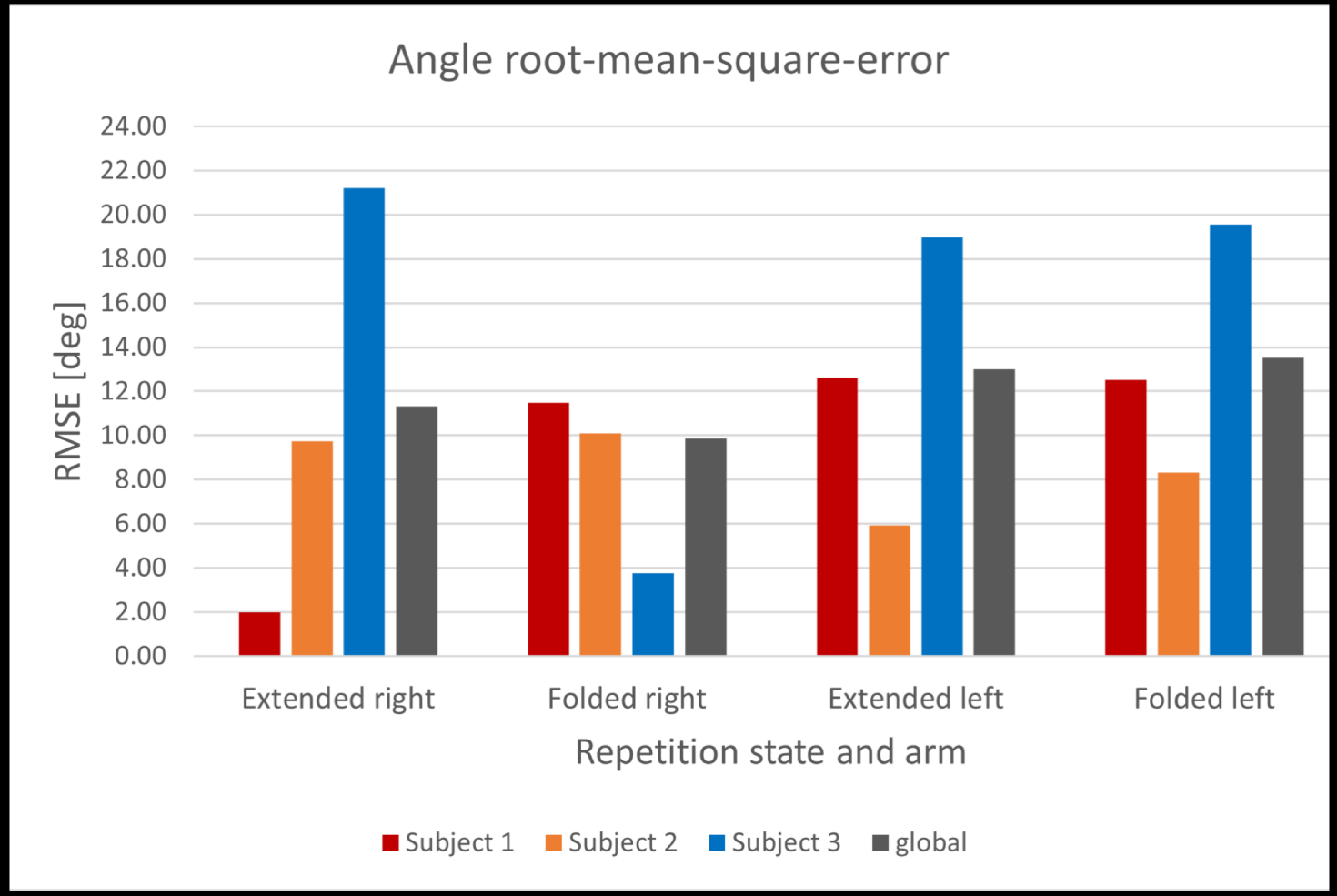
Root mean square error wrt ground truth



Extended ~ 150°

Folded ~ 0°

Total RMSE = 13 deg.



Angle root-mean-square-error of each subject

Standard deviation of the peaks

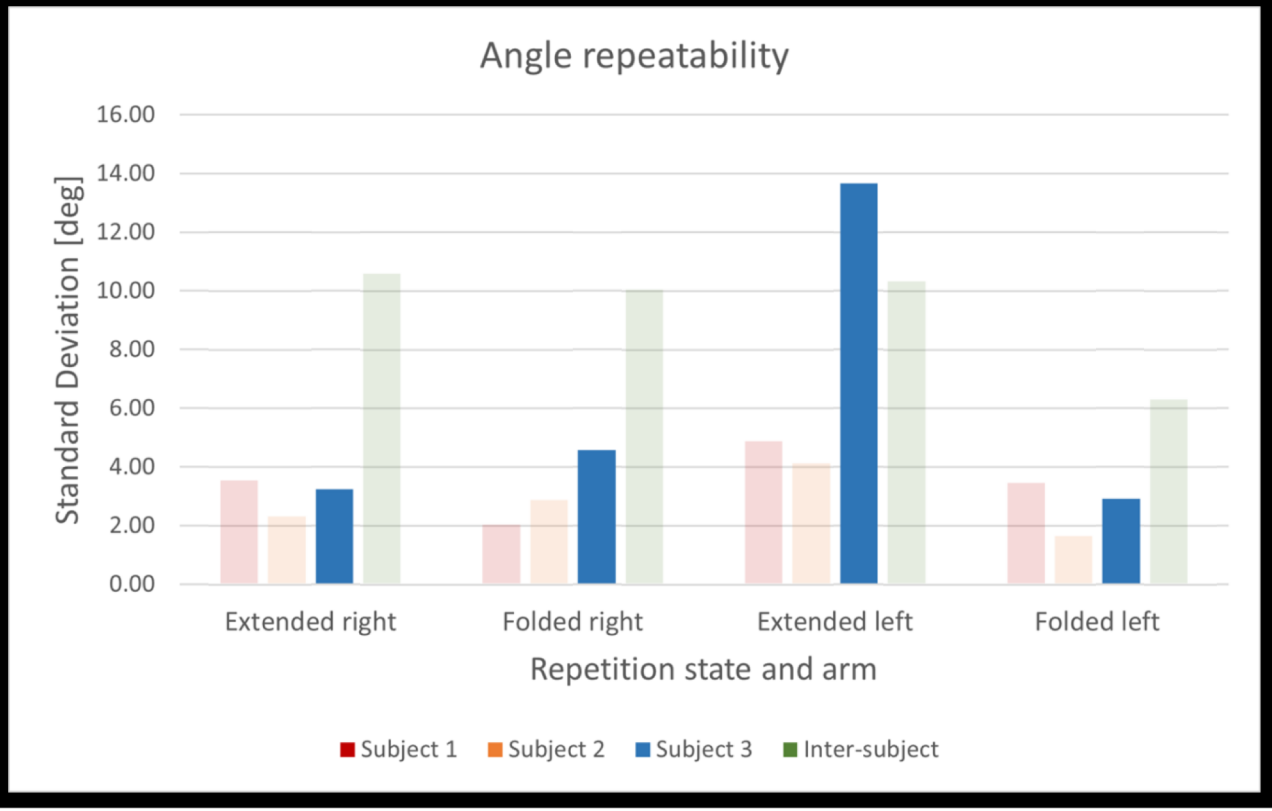


Figure 4. Intra-subject repeatability (red, orange, blue bars); inter-subject repeatability (green).

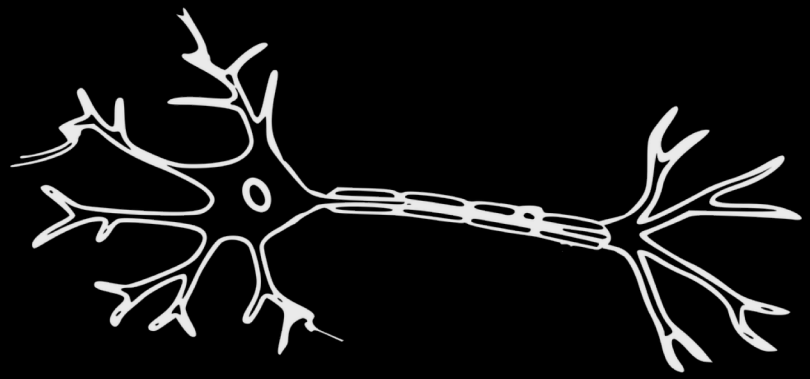
Conclusion

Low inter-sub repeatability:

- Environment condition
- Subjects characteristics

Exercise phase dependency

- Different phase = different results
- Accuracy influenced by the phase



Thank you for your attention

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Our research group

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