2023 SPRING EECE492-01

DEVELOPMENT OF MOTION CORRECTION APPLICATION BY USING ON-DEVICE AI

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1. Research Motivation and Objective

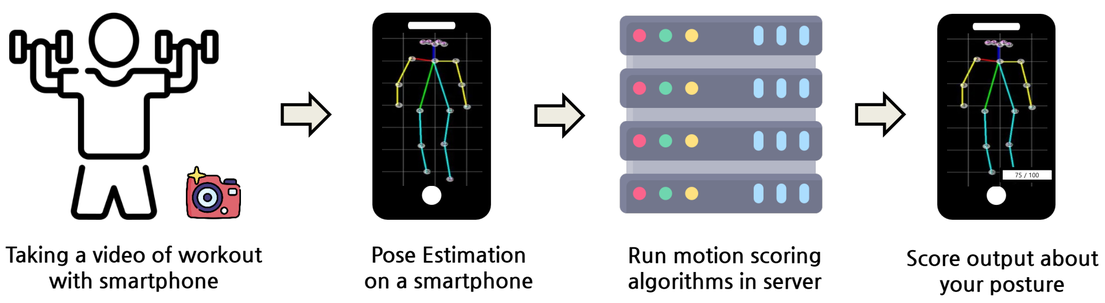
Motivation

Incorrect posture causes injuries when working out. We develop a motion correction solution that allows you to work out safely.

Objective

1. Prevent the risk of injury by correcting the user's workout posture.
2. Find out if your posture is wrong through the evaluated score.

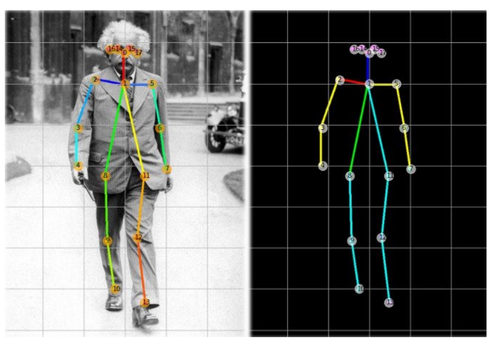
2. Overview of Solution

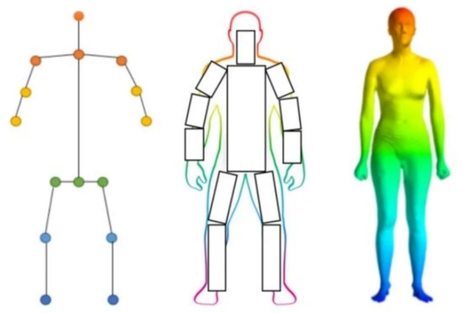


Taking a video of workout with smartphone | Pose Estimation on a smartphone | Run motion scoring algorithms in server | Score output about your posture

3. Theoretical Background

Pose Estimation





(a) Kinematic (b) Planar (c) Volumetric

1. Predict a person's posture by specifying joints or specific parts as keypoints from a image.
2. Widely used in posture correction, VR by rendering human objects in the form of Kinematic, Planar and Volumetric Mesh.

Motion Comparison algorithm

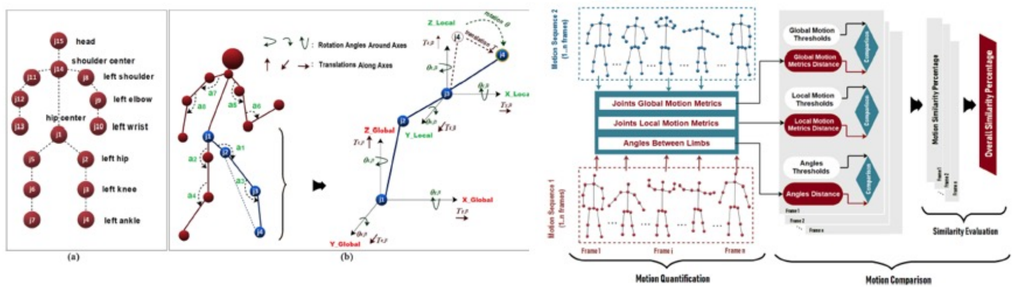


Fig 1. Motion comparison logics in paper

1. Measure the similarity of motion by considering the difference between xy-coordinates, angles, through frames containing keypoints coordinate data of two people.
2. Reference in "Efficient Body Motion Quantification and Similarity Evaluation Using 3-D Joints Skeleton Coordinates" (IEEE, 2021)

4. Pose Estimation model research

Model research and test

	MoveNet	SimpleBaseline	VIBE
Dimension	2D	2D	3D
Approach	Bottom-Up	Top-Down	-
AP	66.7	74.3	63.4
FPS	87	-	30
Dataset Type	Image	Image	Video

1. Selected 3D VIBE model to improve motion comparison algorithm performance by obtaining joint rotation and 3D coordinate information.

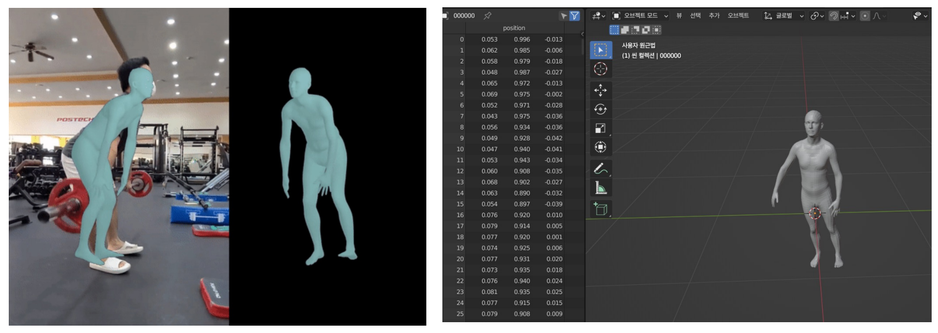


Fig 2. 3D VIBE model demo

2. 3D VIBE model demonstration and obtained data in PC environment.
3. Attempted to convert a 3D VIBE Pytorch model to TFLite for inference in the on-device environment, but failed due to size and version compatibility issues. Therefore, apply the 2D MoveNet TFLite model first.

5. Motion Scoring Algorithm

1. Implement Motion scoring algorithm based on "Efficient Body Motion Quantification and Simplicity Evaluation Using 3-D Joints Skeleton Coordinate" (IEEE, 2011)" in Python.

2. Build an API server that performs Motion scoring algorithm in Python due to low support for matrix operations in the Dart lang.
3. Perform Motion scoring algorithm and return similarity in API server by using keypoints data obtained by inference from smartphones.

6. App development

1. App development in Flutter (Android / iOS)
2. On-device AI inference through float16 type light-weighted model.
3. App Flow: Select a specific workout -> Take a user workout and inference pose estimation in smartphone -> Perform motion scoring algorithm between user and expert videos-> Print user's posture score

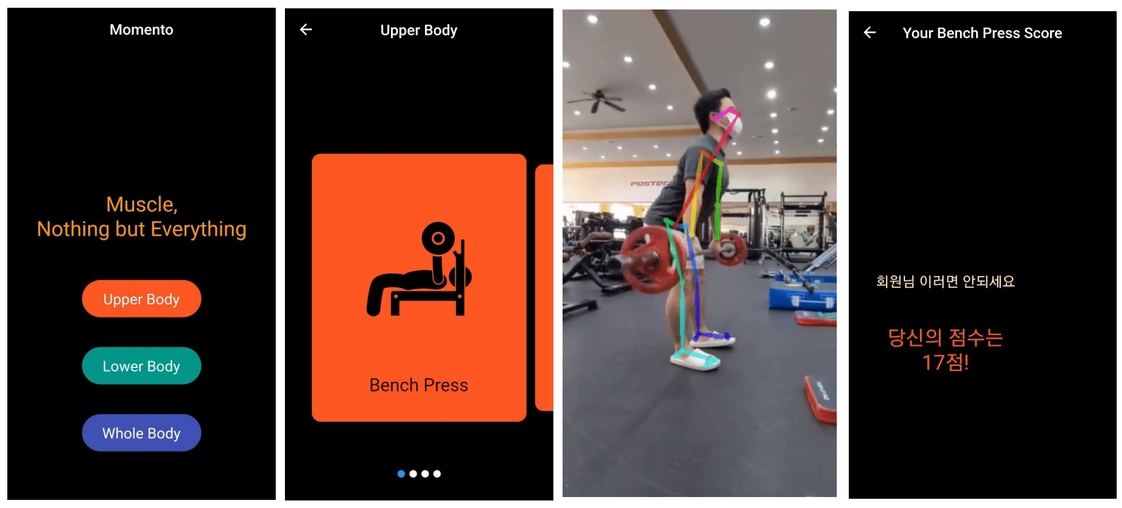


Fig 3. App flow

7. Conclusion

Summary

1. Perform real-time Pose Estimation inference in on-device environment and extract keypoints coordinate of workout posture.
2. Implement of motion scoring algorithm based on the paper to calculate similarity between user and expert's posture.
3. Develop a service as a versatile smartphone app. (Android / iOS)

Expectation

1. Workout posture correction and scoring
   - Reduce the risk of injury by evaluation your workout posture.
   - If the posture improvement guideline feature is added, people can increase there efficiency of workout by themselves.
2. App with On-device pose estimation & motion comparison algorithm
   - Can apply developed technologies to small computing devices.
   - Can be used for applications that preserve data privacy like human detecting CCTV, motion based passwords, etc.