NICOGRAPH International 2019

Visual Feedback for Core Training with 3D Human Shape and Pose

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BACKGROUND:

Core Training

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https://www.youtube.com/watch?v=V7SF9Vwb1aQ

sold 1,200,000 copies

BACKGROUND:

Open Pose [CVPR2017]

INPUT

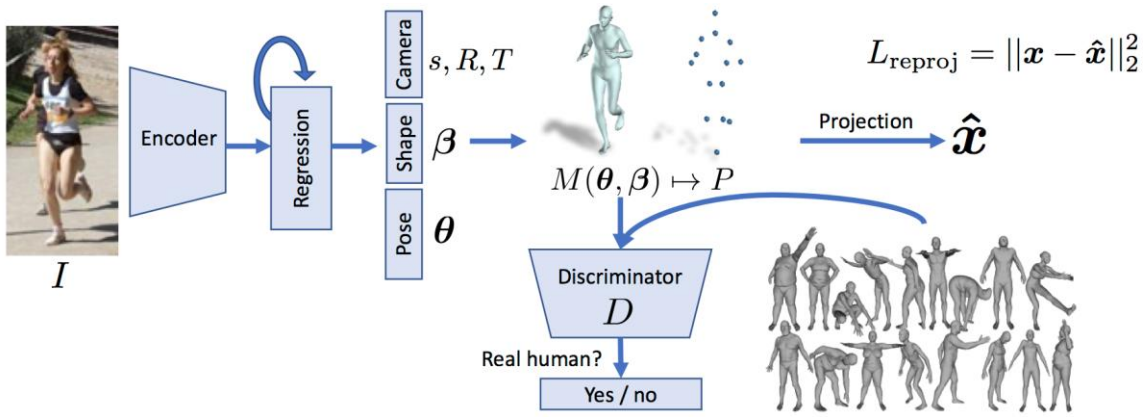
Confident Map

Part Affinity

Z. Cao et al,. Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields. CVPR2017

BACKGROUND:

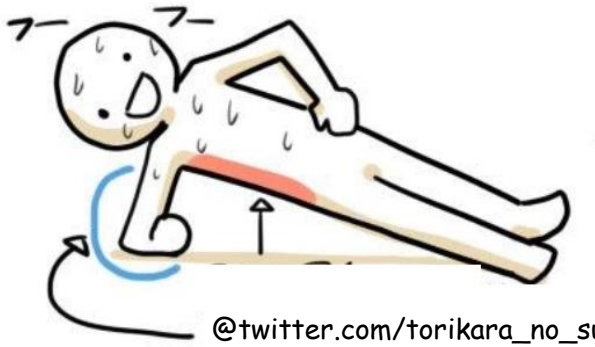
Human Mesh Recovery [CVPR2018]



A. Kanazawa et al,. End-to-end Recovery of Human Shape and Pose. CVPR2018

Motivation

Core Training Issues



@twitter.com/torikara_no_su

1. Difficult to achieve target poses
2. Injury if in an incorrect pose

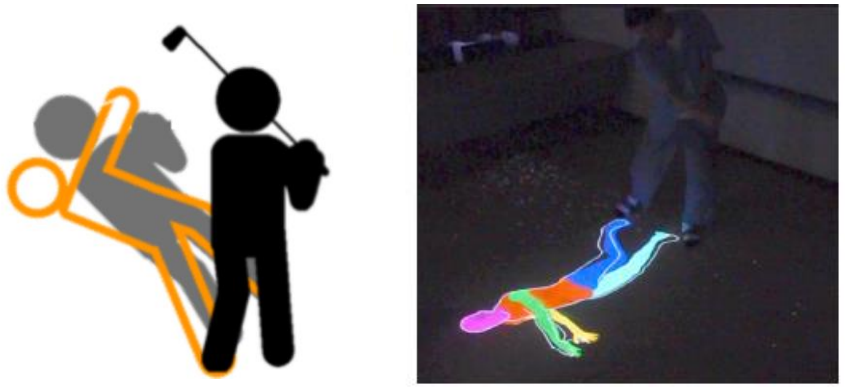
Existing Training System

Gymnastics Training System @Fujitsu,2017

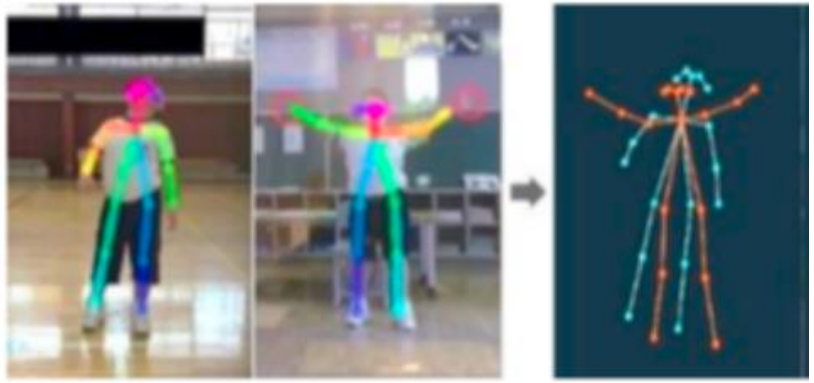
1. Expensive for common users
2. Need special devices
3. Using 2D skeletons
4. Difficult to use

Related Works

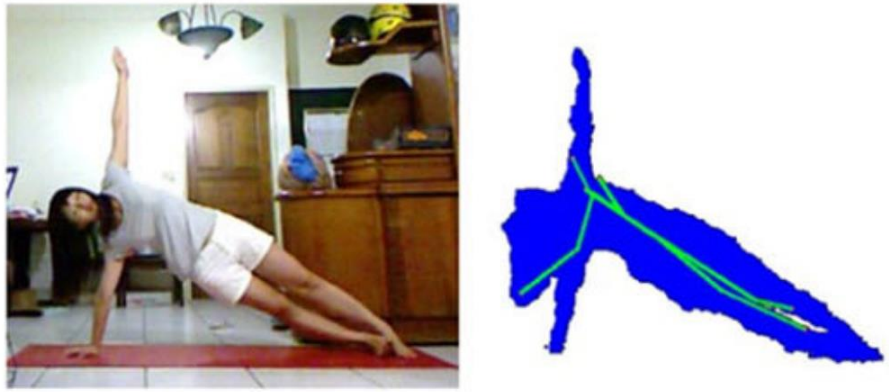
Strength training systems, IPSJ2015



Golf training systems, ISS2018



Physical training systems, FIT2018

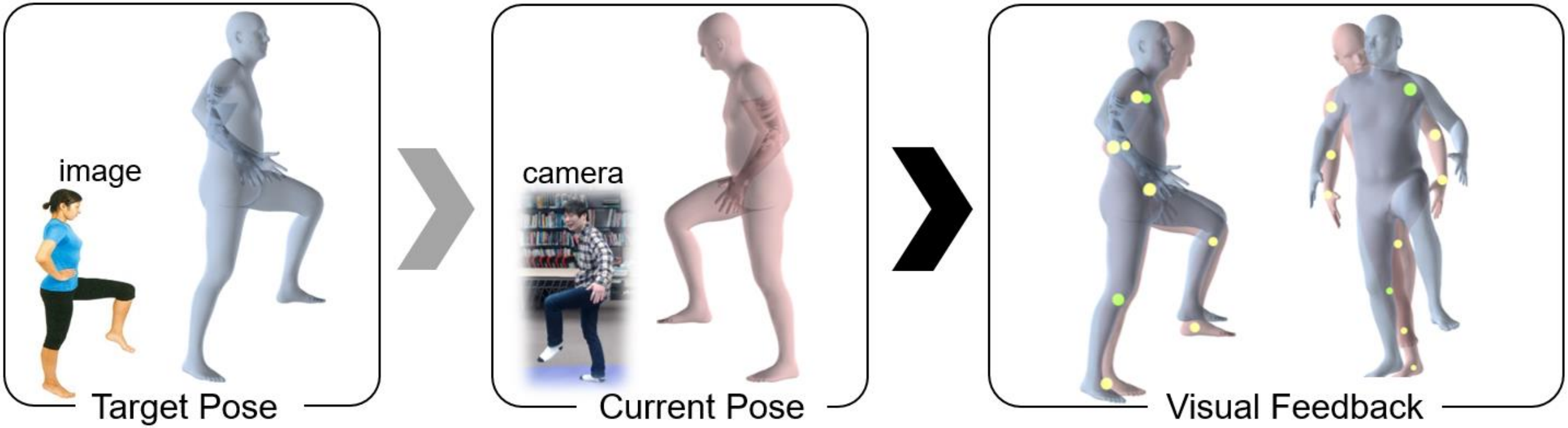


Yoga training systems, Multimed Tools Appl (2018)

2D skeletons from Depth Sensors (Kinect)

2D Silhouette from Cameras

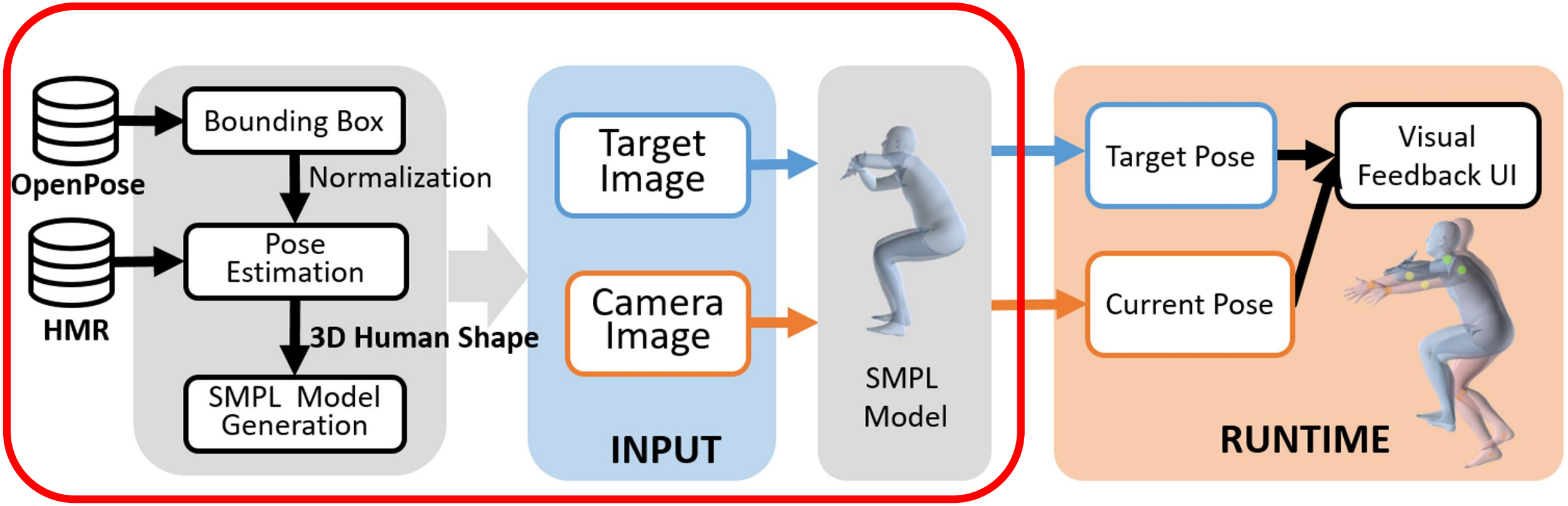
Contributions



1. Expensive for common users ⇢ 1. Available for common users
2. Need special devices ⇢ 2. Using normal web-camera
3. Using 2D skeletons ⇢ 3. Adopting 3D human shapes
4. Difficult to use ⇢ 4. Providing simple user interface

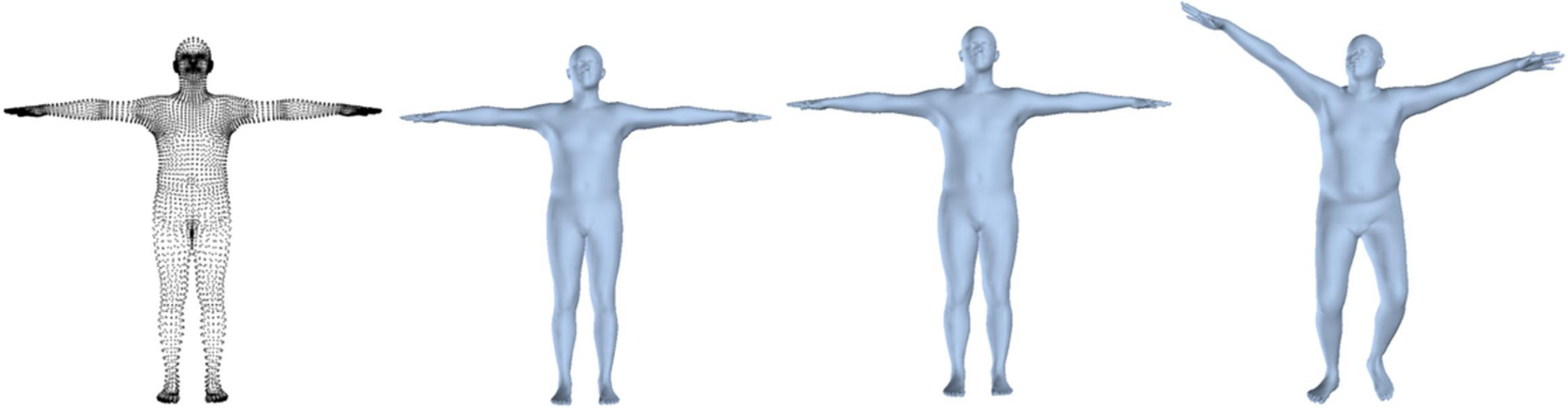
Deep learning based approach

Framework


OpenPose
HMR
Bounding Box
Normalization
Pose Estimation
3D Human Shape
SMPL Model Generation
Target Image
Camera Image
INPUT
SMPL Model
Target Pose
Current Pose
Visual Feedback UI
RUNTIME

SMPL[SIGGRAPH Asia 2015]

A Skinned Multi-Person Linear Model

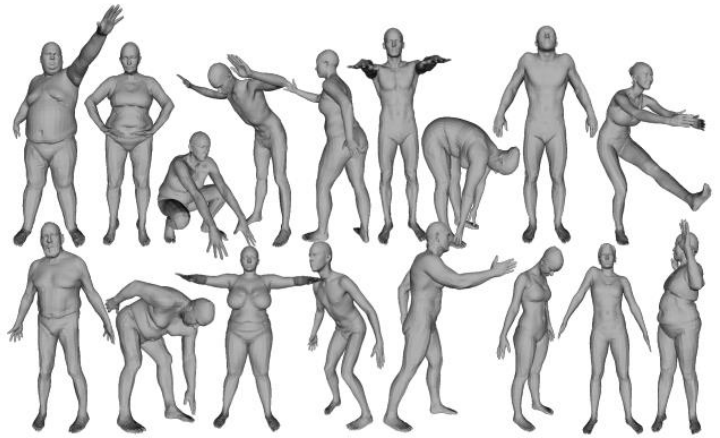


$N = 6{,}980$ $M(0,0)$ $M(0,\beta)$ $M(\theta,\beta)$

Model Meshes $M(\theta,\beta) \in \vec{R}^{3\times N}$

Pose parameters $\theta \in \vec{R}^{3\times K+3}$

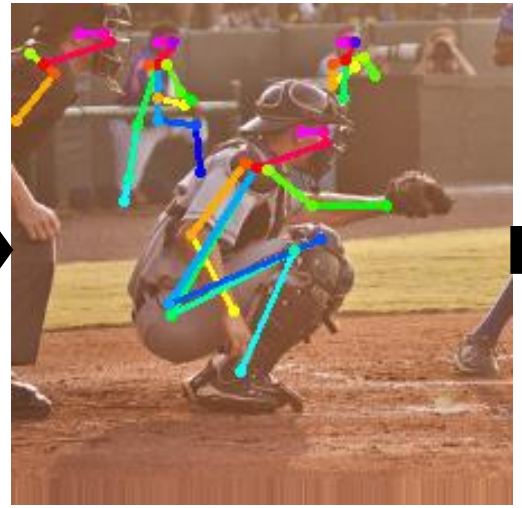
Shape parameters $\beta \in \vec{R}^{10}$ $K = 23$ joints



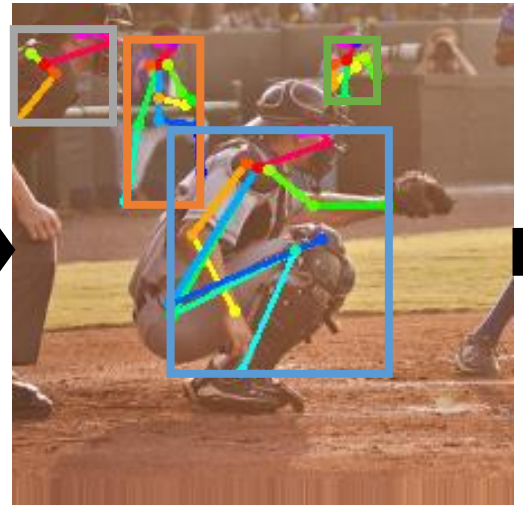
Loper, Matthew, et al,. SMPL: A Skinned Multi-Person Linear Model. TOG2015

SMPL Model Generation

INPUT Image



Joints Estimation
(openpose)

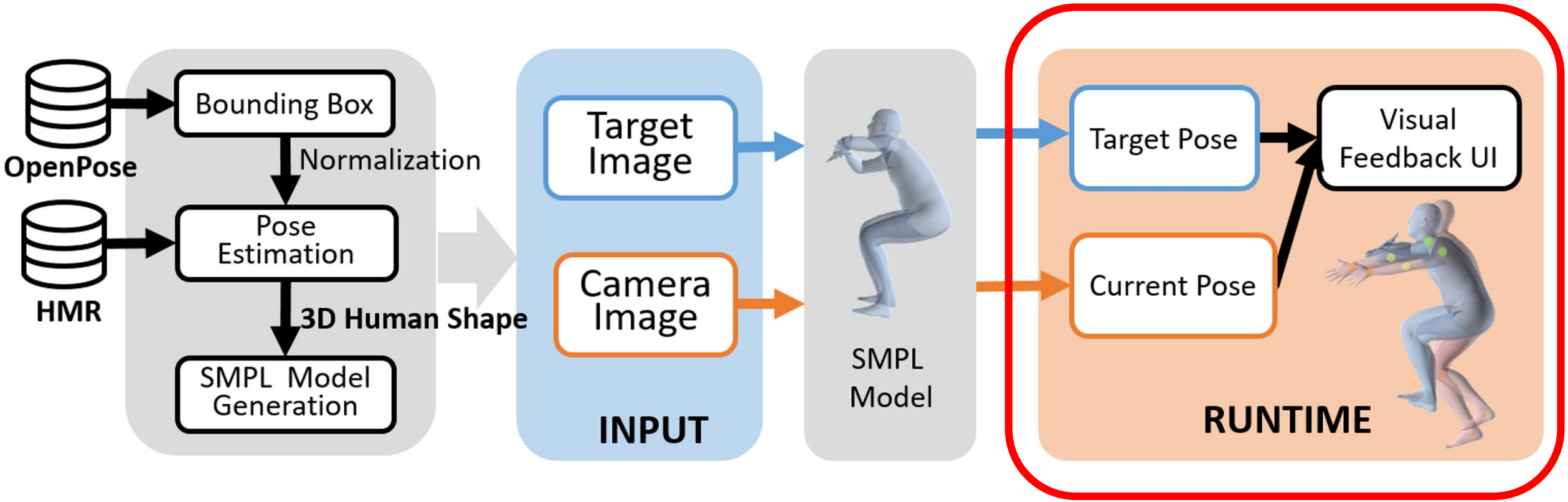


Bounding Box

3D Pose Estimation
(Human Mesh Recovery)

3D Shape Generation

Framework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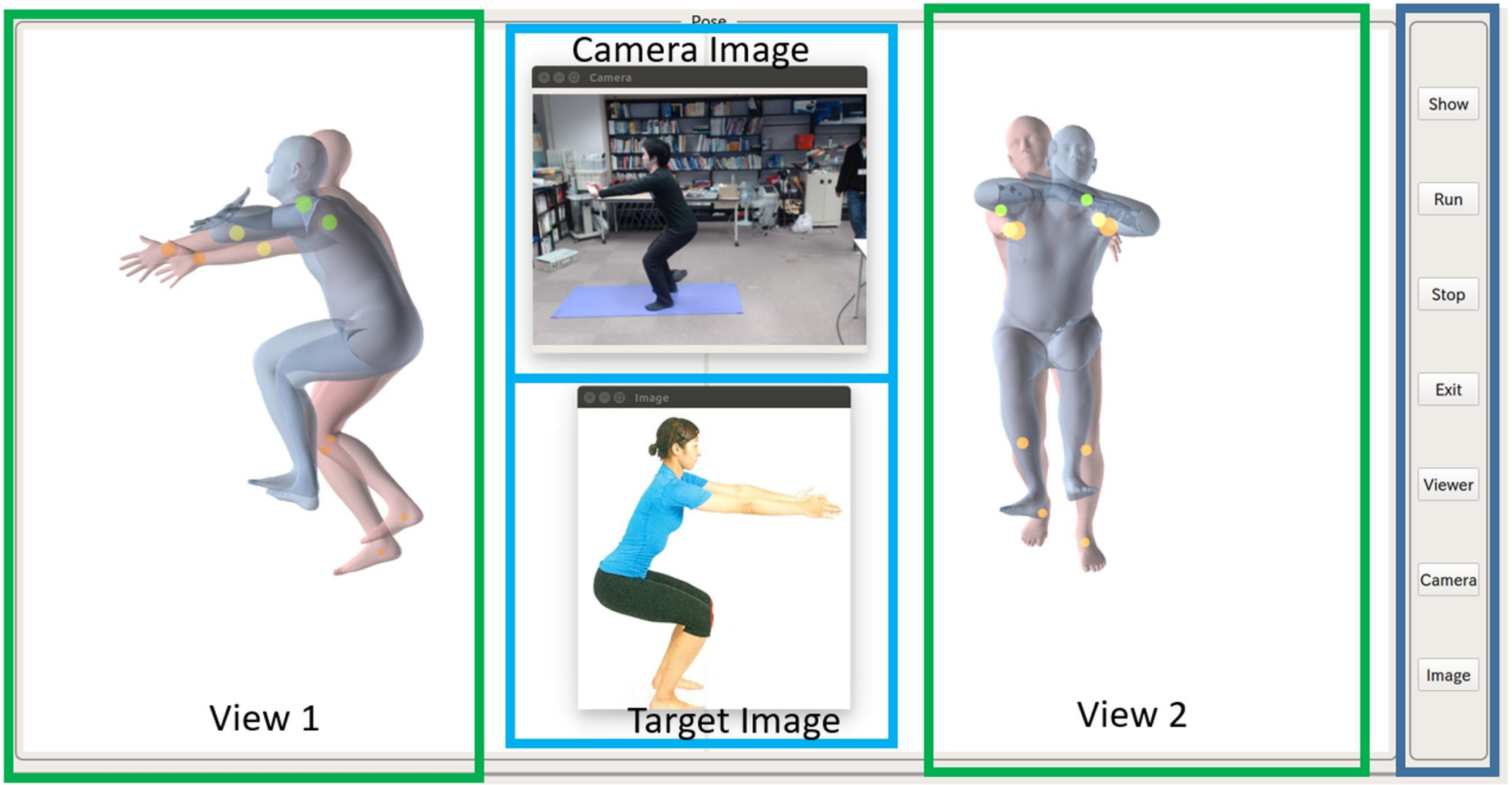
Visual Feedback UI
RUNTIME

User Interface

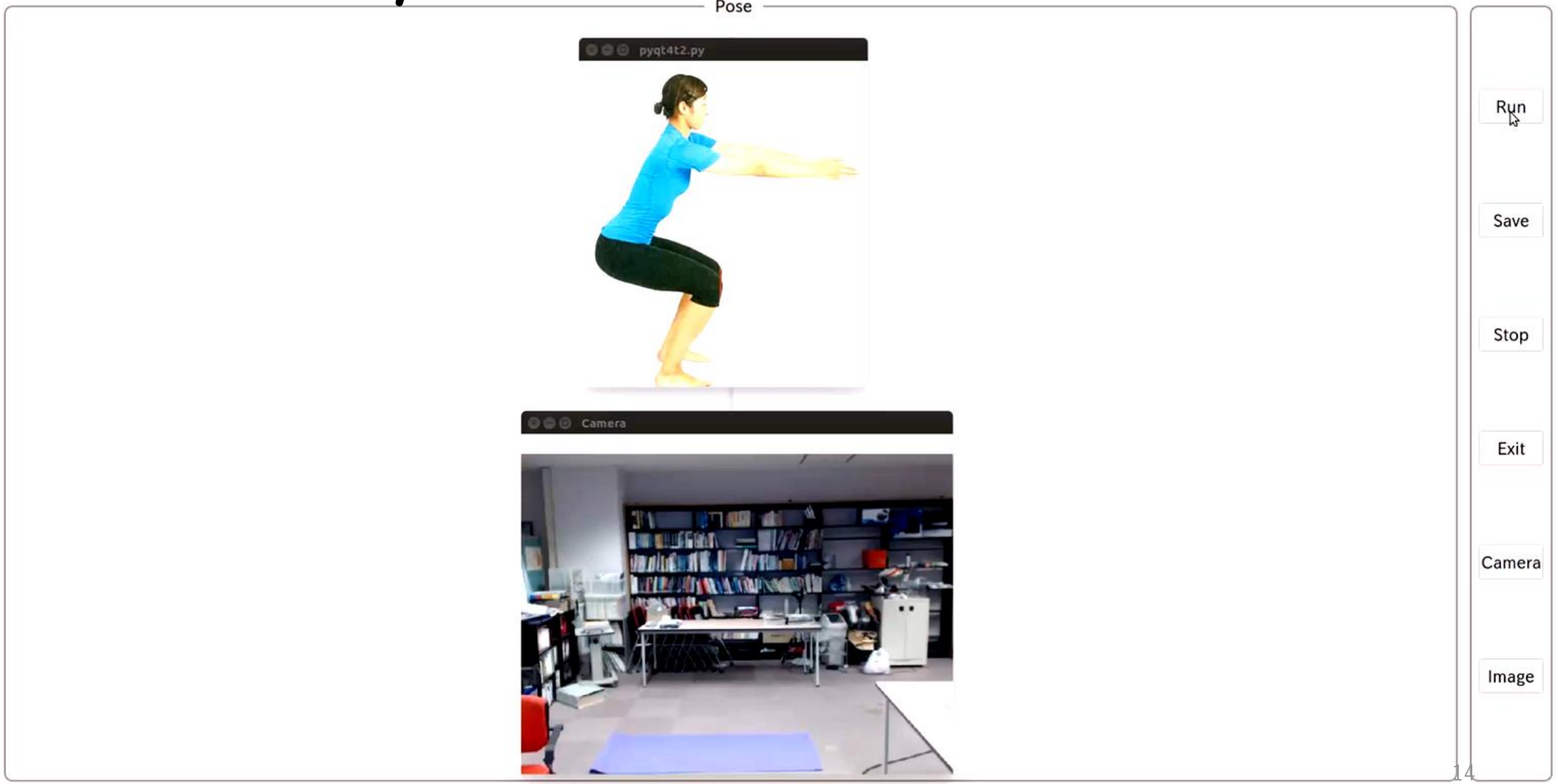
Visual Guidance

Makers' positions: 10 (hands, elbows, shoulders, knees, ankles) *2

Makers' colors far close



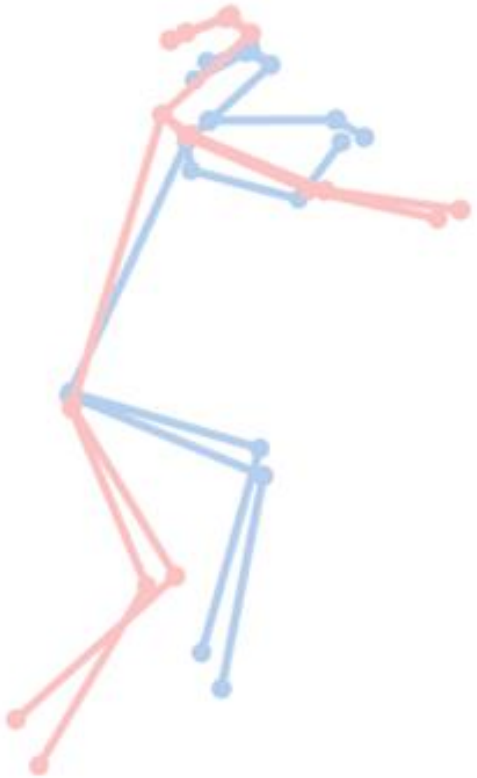
User Study



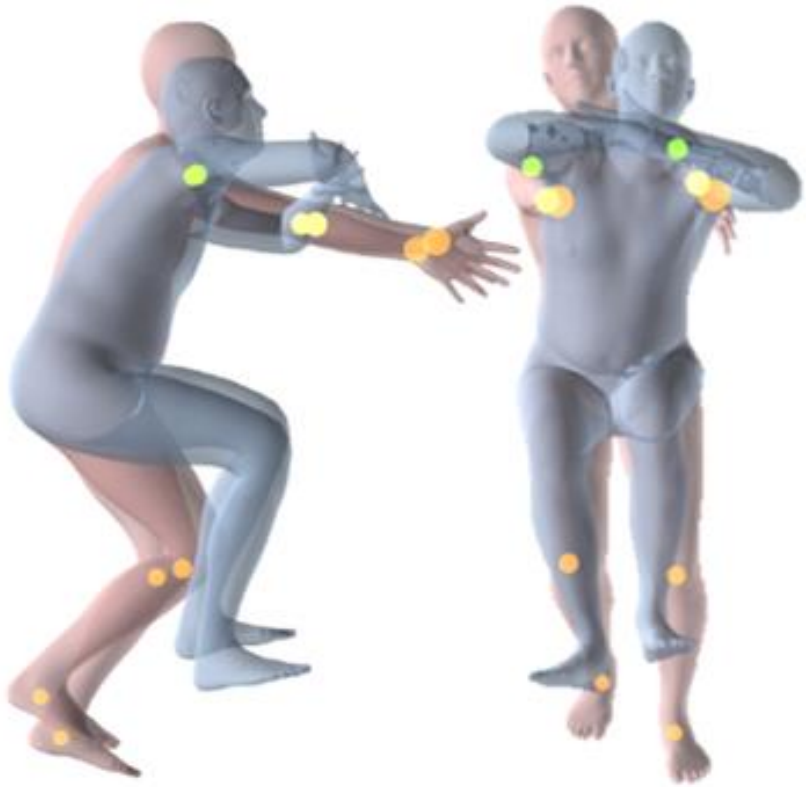
Results

OS : Ubuntu 16.04.5 LTS (Xenial Xerus)
CPU : Intel® Core™ i5-4690 CPU@3.50GHz
GPU : Geforce GTX 1060 6GB
RAM : 16GB
CUDA : 8.0.61
cuDNN : 6.0.21
Tools : Pyenv, Pyenv-virtualenv

Comparison Study

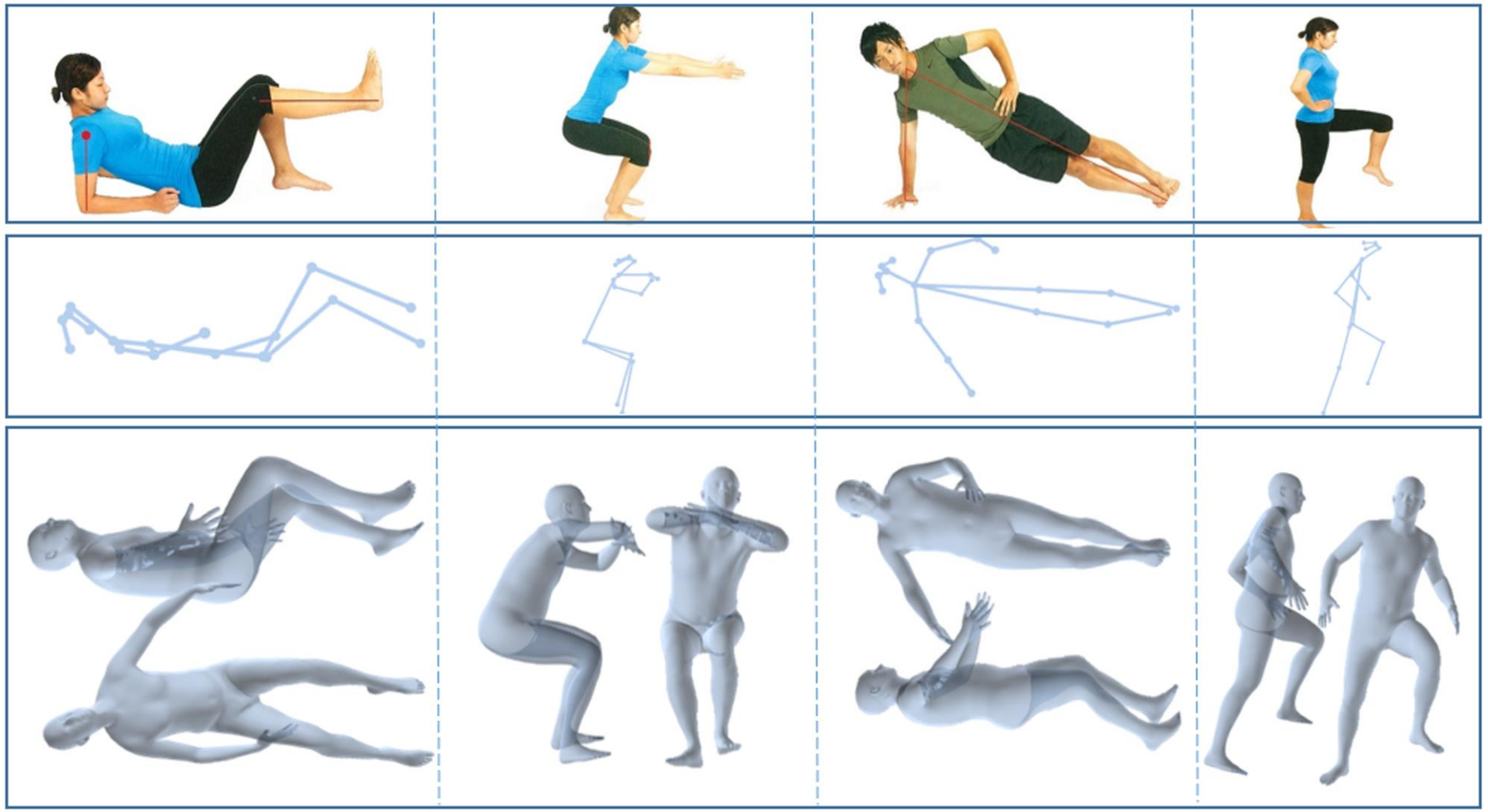


(1) Skeleton guidance



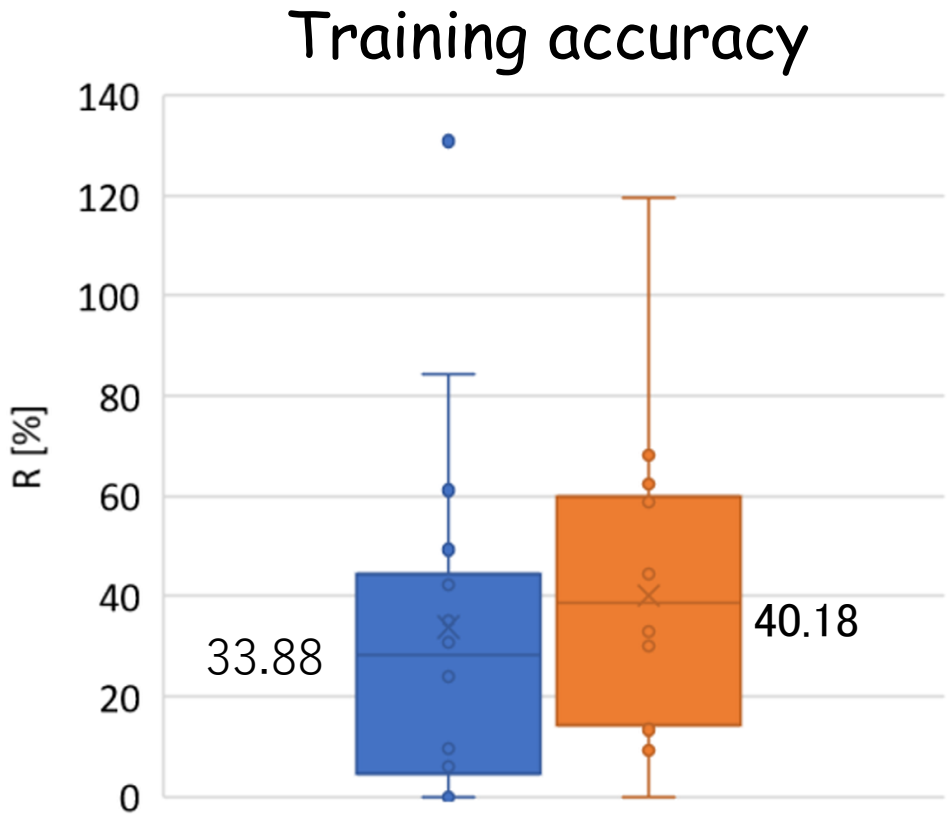
(2) Our guidance

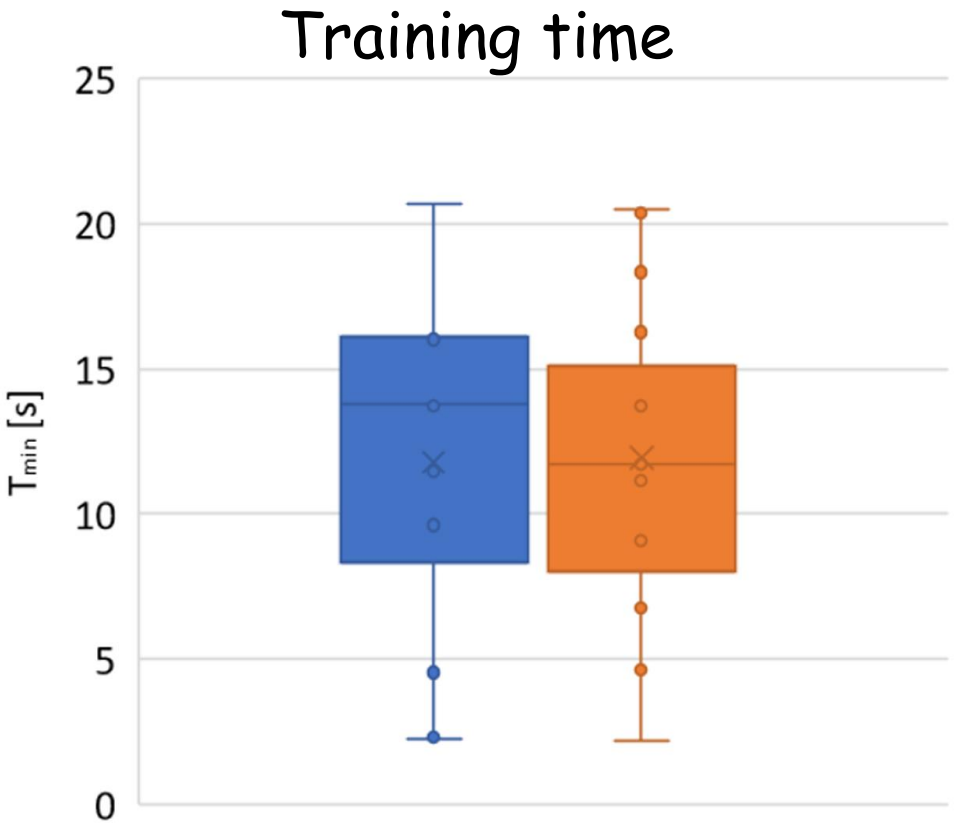
Evaluations: tasks



8 participants (Male, Age 24.2±1.05)

Evaluations: results





skeleton guidance (2D)

our guidance (3D)

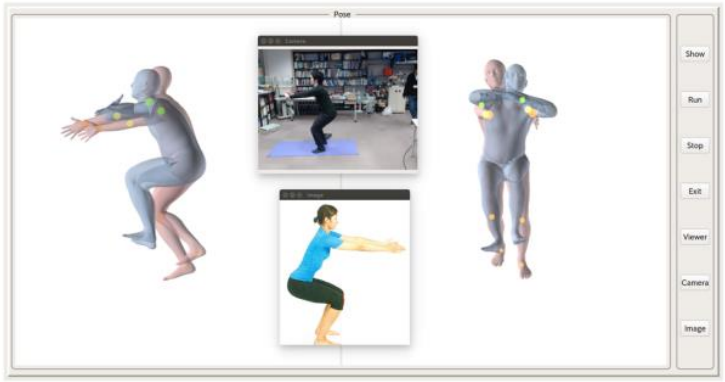
$$RMSE_i = \sqrt{\frac{1}{N}\sum_{k=1}^{N}(\vec{E}_k(t_i) - \vec{M}_k(t_i))} \qquad N = 5,628$$

current target

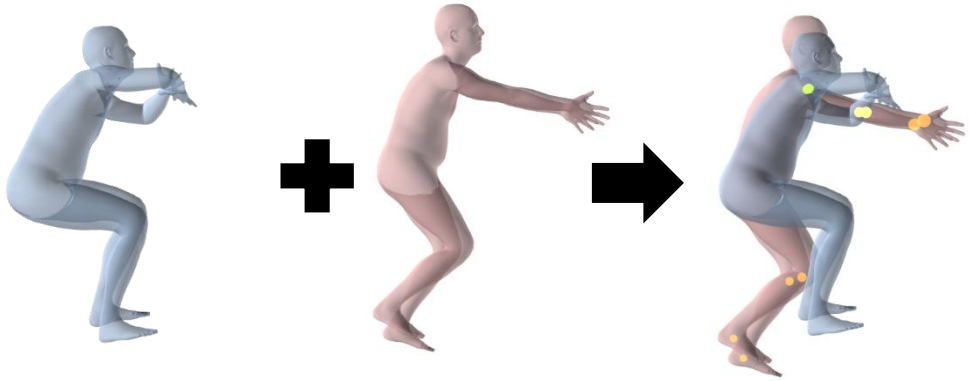
Training accuracy $$R = \frac{RMSE_0 - RMSE_{min}}{RMSE_0} \times 100$$

Conclusion

1. User interface for core training from a web camera



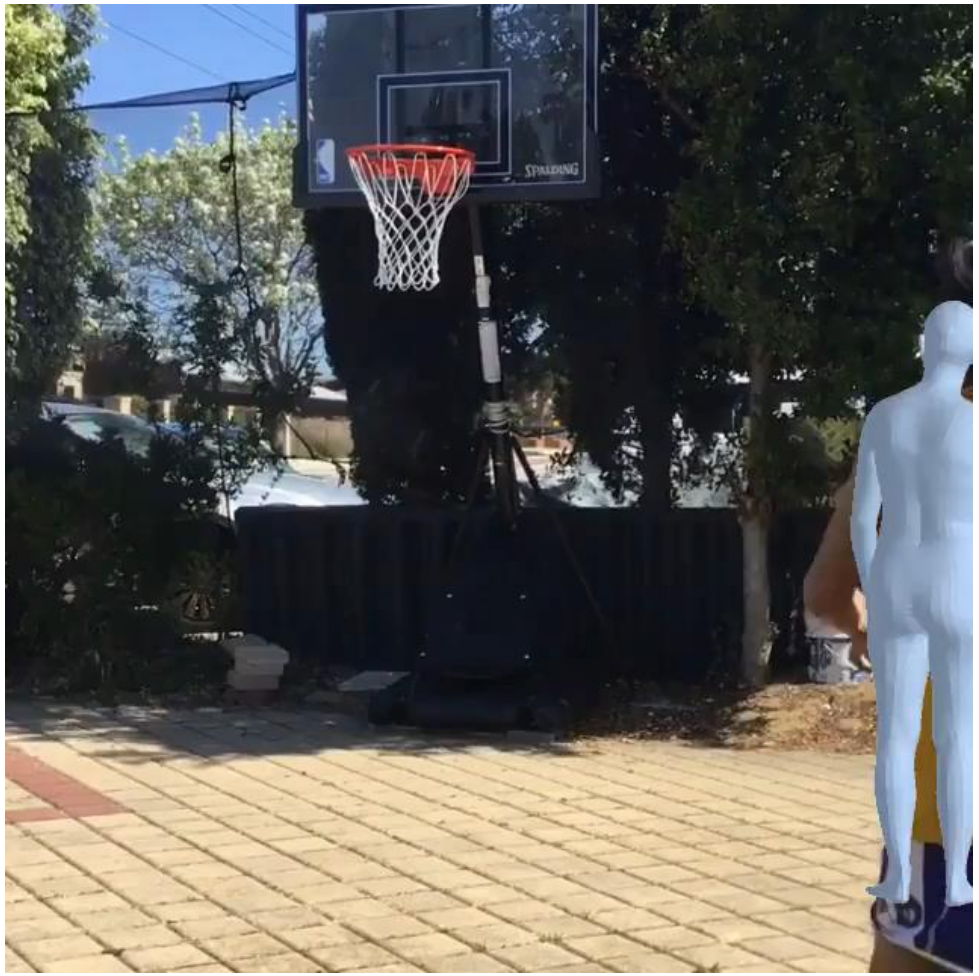
2. Multiple-view 3D human pose based on OpenPose and HMR models



Limitation

1. Computation costs (2 seconds /frame)
2. Body shape alignment on root
3. Dynamical sport training
4. High-level visual guidance

More Sports, More UIs



Learning 3D Human Dynamics from Video. CVPR2019.

Thank You!

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