Synthetic images of human skeletal motion for pose and kinematics estimation tasks

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Summary

We present software for generating synthetic images of musculoskeletal modeling-based human kinematics. The images are automatically annotated with joint positions and modelled parameters of the motion. The software can be used for generating customized image data for supervised learning methods such as training human pose estimation models.

Introduction

Human pose estimation (HPE) models have been adapted in the study of human motion to track anatomical landmarks (keypoints) from video feed [1, 2]. The detected keypoints can then be used in inverse kinematics tasks to simulate the motion of the subject with musculoskeletal (MSK) modeling [1, 2]. However, existing HPE models are usually trained on image data that is not specifically aimed at biomechanical uses [3], meaning that the keypoint annotations in the training data are approximate and training data is difficult to find for specific motion types or conditions. To tackle these issues, we present software for generating images of motion that are based on MSK models.

Methods

We used an existing body shape modeling tool [4] to create realistic meshes of the human skin surface. We then integrated the skeletal structures of scaled MSK models into the skin meshes. We moved the resulting skeleton-actuated skin meshes to a game engine to enable realistic visual effects and to animate the meshes using kinematics analyzed with OpenSim (**Figure 1**). Finally, we generated synthetic images of skeletal motion and automatically annotated them with keypoints by projecting 3D points from MSK modeling to the 2D coordinate system of the generated images.

Results and Discussion

Using the posed meshes and various backgrounds, body types, textures, and camera parameters, we can generate an arbitrary number of images of human motion and automatically annotate them with known joint locations and other information (**Table 1**). Hence, the software could be used for generating motion- or condition-specific data for training HPE models. While similar solutions exist [5], our software utilizes OpenSim, which allows generating image sequences labeled with MSK information, e.g., generalized coordinates (joint angles) of the MSK model.

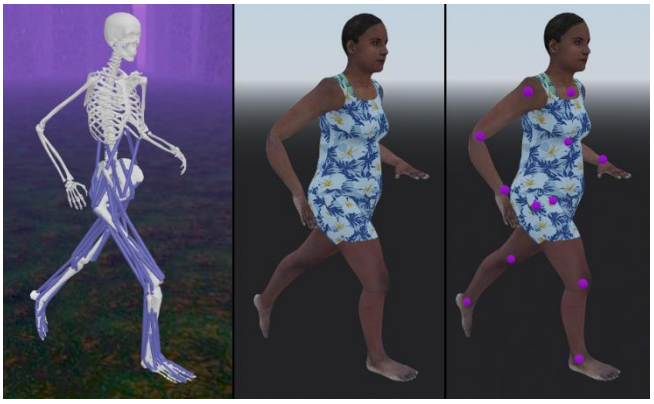

Figure 1: We visualize kinematics from musculoskeletal simulation (left) using realistic skin meshes (middle), allowing the generation of synthetic images with annotated joint locations (right).

Conclusions

We present software for generating automatically annotated images of MSK motion. The generated data could be used for HPE training tasks and for other motion visualization purposes. We are still honing the software and seek feedback from the MSK modeling community. We plan to release the final software and sample datasets openly. In the future, we will use the generated data to train HPE models for human motion analysis purposes.

Acknowledgments

We utilize human models and textures from the SKEL [4] and BEDLAM [5] projects.

References

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Table 1: Overview of the annotations and labels that are automatically created for each generated image.

Images (1024x1024)	color image of visualized motion, mask image of the person's silhouette, mask images of individual limbs
Annotated 2D keypoints and coordinates	joint positions, origins of bodies of the MSK model, bounding box enclosing the person, depth (distance from the camera) of keypoints in the image
Other metadata	self-occlusion state of 2D keypoints, body morphology type of the person, sex of the person, camera position, camera field of view, values of generalized coordinates (joint angles) of the musculoskeletal model