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CONFIDENCE-BASED INVERSE KINEMATICS METHOD FOR MARKERLESS MOTION CAPTURE: PRELIMINARY RESULTS

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Introduction

Markerless motion capture methods are expected to allow for lighter motion analysis setups, especially compared with optoelectronic systems. Using videos, pose estimation software generate a 2D confidence heatmap for each keypoint [1]. 2D keypoints are then generally defined as the pixel with the maximum confidence value over the heatmap. A confidence-weighted direct linear transform (wDLT) is used to obtain 3D points. Joint angles are finally obtained using multibody kinematics optimization (MKO). MKO consists in minimizing the distance between experimental and model-derived points. Isakov et al., [2] showed the interest of using 3D heatmaps, especially with few cameras. However, the whole 3D confidence information was finally summarized to 3D points only. In this preliminary study, we proposed and evaluated a novel MKO method using the complete 3D confidence information with a minimal number of cameras, and compared it with the wDLT method.

Methods

One participant (female, 22 years old, 1.68m, 55kg) has performed 4 tasks: treadmill walking (Walk) for 12 seconds, 3 countermovement jumps (CMJS), 3 stair ascents and descents (Stair), 3 sit-to-stands (STS). Data was collected simultaneously using a 10-camera optoelectronic marker-based system and two video cameras, positioned symmetrically with an angle of 45° with the sagittal plane of movement. The two camera systems were calibrated and synchronized. The participant was equipped with a full-body set of 46 markers. Marker-based data was labelled and gap-filled.

OpenPose [1] was applied to the videos. For each of the 20 keypoints of interest, associated 2D confidence heatmap and position in the image reference frame were obtained. 3D keypoints trajectories were obtained from wDLT and gap-filling. In parallel, each 2D confidence heatmap was parametrized as a 2D gaussian with 5 parameters. 3D confidence value was computed for any 3D point by projecting it on the heatmaps of the two cameras and by summing the 2D confidence values obtained using the gaussian parameters.

Two whole body models with the same structure were defined according to the available inputs (markers or keypoints). Three sets of joint angles (hip, knee and ankle flexion/extension) were obtained using MKOs: classical MKOs using markers or wDLT reconstructed keypoints and a novel MKO based on HMP. Starting from the wDLT initial solution (model dimension and pose at the 1st frame), the joint angles were obtained by

maximizing the sum of 3D-confidence for each of the 20 keypoints.

Bland-Altman bias was computed between the obtained markerless and marker-based joint angles. Unbiased RMSE was also derived by adding the corresponding bias to marker-based joint angle.

Results

	HIP		KNEE		ANKLE	
	b	u	b	u	b	u
Walk	-20.4°	2.9°	-6.1°	3.8°	-4.9°	6.8°
CMJS	-24.4°	3.5°	-3.2°	3.4°	4.8°	3.6°
Stair	-23.7°	5.0°	-3.9°	4.6°	1.2°	9.1°
STS	2.0°	2.6°	1.0°	3.6°	7.8°	2.5°

Table 1: Bias (b) and unbiased RMSE (u) between wDLT and marker-based joint angles.

	HIP		KNEE		ANKLE	
	b	u	b	u	b	u
Walk	-21.6°	3.7°	-8.2°	4.2°	-5.0°	4.0°
CMJS	-25.9°	3.6°	-4.2°	3.6°	4.8°	5.5°
Stair	-24.0°	5.1°	-4.7°	6.8°	2.3°	9.2°
STS	2.2°	4.6°	0.9°	4.3°	8.4°	2.7°

Table 2: Bias (b) and unbiased RMSE (u) between HMP and marker-based joint angles.

Except for STS movement, hip flexion/extension was always underestimated by more than 20° using markerless methods. This difference comes from the definition of the pelvis segment, which was done while sitting for STS and standing for the other movements. Unbiased RMSE was smaller using wDLT than HMP in mostly all cases, but the differences were usually less than 1°.

Discussion

This preliminary study suggests that HMP method provides results similar to wDLT. However, it would be interesting to perform the same comparison when some keypoints are occluded. Indeed, when a keypoint is occluded it is impossible to perform wDLT as there is only one camera left, but 3D confidence information of the remaining camera is still available. It is thus expected that HMP method would produce results based on the actual data, even in the case of occluded keypoints.

References

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