# VALIDATION OF A MARKERLESS MOTION CAPTURE SYSTEM FOR THE CALCULATION OF LOWER EXTREMITY KINEMATICS

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## INTRODUCTION

New methods for the capture of human movement motivated by technological advances aiming to use non-intrusive or markerless motion capture [1] offer the potential to address some of the limitations of current methods for human gait analysis and open the door for new opportunities for the study of normal and pathological motion. While theoretical studies [2,3] showed that human kinematics can be accurately estimated in a virtual environment, these methods have not been tested with laboratory data. The purpose of this study was to evaluate the accuracy of human body kinematics extracted from experimental data using a visual hull markerless motion capture system.

## METHODS

Full body movement was captured using a marker-based and a markerless motion capture system simultaneously. The marker-based system consisted of an 8 Qualisys camera optoelectronic system monitoring 3D marker positions for the hip, knees and ankles at 120 Hz. The markerless motion capture system consisted of 7 Basler CCD color cameras capturing synchronously images at 76.9 fps. Movement was determined by first constructing visual hulls [2] and subsequently tracking an articulated body using an iterative closest point (ICP) tracking algorithm for articulated bodies [3]. The subject was separated from the background in the image sequence of all cameras using intensity and color thresholding compared to background images (Figure 1). The separated image information was projected into 3D and a visual hull (bounding surface) was constructed for each frame (Figure 2). The articulated body was created from a detailed full body laser scan with markers affixed to the subject's joints (Figure 1). The articulated body consisted of 15 body segments (hip, upper trunk, head, and left and right shoulder, forearm, hand, thigh, shin and foot) and 14 joints connecting these segments. Virtual markers were used to define segment coordinate axes. The joint angles (sagittal and frontal plane) for the knee calculated as angles between corresponding axes of neighboring segments, were used as preliminary basis of comparison between the two systems.

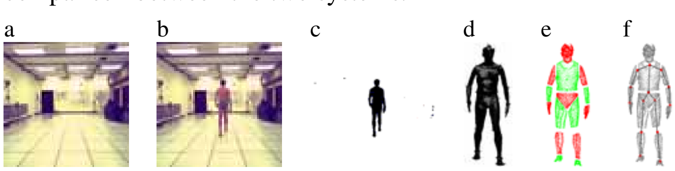

**Figure 1:** a) Background image. b) Image. c) Separated subject data. c) Laser scan. d) Body segments. e) Joint centers.

## RESULTS

The 15 articulated body segments defined from the laser scan were tracked through a gait cycle for both the markerless and marker system (Figure 2). The kinematics from the markerless and marked system produced comparable results (Figure 3) for knee joint angles in the sagittal and frontal plane.


**Figure 2:** Visual hulls constructed using 7 cameras (top). Articulated body matched to visual hulls (bottom).

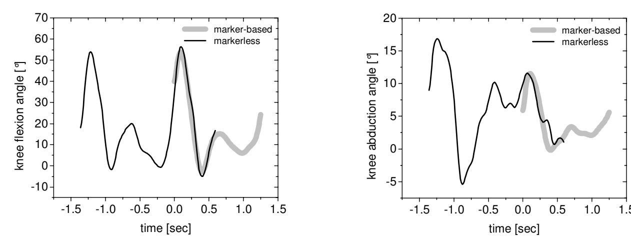

**Figure 3:** Motion graphs for knee flexion and knee abduction angles (gray = marker-based; black = markerless).

## DISCUSSION

The image processing modules used in this study including background separation, visual hull and iterative closest point methods yielded results that were comparable to a marker based system for motion at the knee. While additional evaluation of the system is needed, the results demonstrate the feasibility of calculating meaningful joint kinematics from subjects walking without any markers attached to the limb.

The markerless framework established in this study can serve as a basis for developing the broader application of markerless motion capture. Each of the modules can be independently evaluated and modified as newer methods, cameras and processors become available, thus making markerless tracking a feasible and practical alternative to marker based systems.

## REFERENCES

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