AN ALGORITHM TO COMPUTE ABSOLUTE 3D KINEMATICS FROM A MOVING MOTION ANALYSIS SYSTEM

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INTRODUCTION: Recently, Colloud *et al.* showed the feasibility of using a *moving* motion analysis system to acquire three dimensional (3d) kinematics over a large volume. They placed a motion analysis system on a rigid rolling frame that followed the displacement of a known object. In this pilot study, Colloud *et al.* obtained accuracy similar to those report for motion analysis systems (Richards, 1999). As a result, the rolling system is accurate enough for capturing the local 3d kinematics. However, the expression of the kinematics in a global frame – *i.e.* the absolute kinematics – has not been assessed. Thus it is impossible to calculate spatial-temporal parameters (*e.g.* step length, step width, walking speed in gait analysis). The purpose of this study is to propose an algorithm for calculating the 3d global kinematic of a subject walking on a 40 m-long pathway.

METHODS: One male participant (age: 21 yr, height: 170 cm, mass: 62 kg) equipped with 22 reflective markers performed five trials on 40 meters. He was followed by a rolling frame (4.4 × 4.0 × 2.5 m) with a 8-camera motion analysis system (T40 series, Vicon, Oxford, UK) sampled at 100 Hz. Forty-one reflective markers were placed every meter on the ground on an horizontal line using a tape measurer and a self levelling laser. The algorithm consists in three steps: (*i*) estimation of the kinematics from the camera frame (A_L) to a local frame (A_i) using two markers (g_i and g_j) seen on the ground, (*ii*) expressed this local kinematics in a global frame (A_G) and (*iii*) calculation of the roto-translation (${}^iR_j$) from this current local frame (A_i) to the next local frame (A_j) before g_i disappears. This last step requires three visible ground markers (g_i, g_j and g_k). An elimination procedure that minimizes the norm of Frobenius is used until 50% of the image remained. The accuracy and precision of the reconstruction were evaluated as the deviation of reconstructed marker position relative to its reference and as the radius of the spheres of 95% confidence for the ground markers express in the global frame, respectively.

RESULTS and DISCUSSION: The accuracy was up to 16 mm in antero-posterior direction but could reach 138 and 163 mm in lateral and vertical directions over the 40 m translation. The deviations differed in direction and magnitude between the trials. The precision was lower than the precision estimated with a rigid object (1.3 mm). Although their position was fixed in the global frame, the markers were shaking, in the worst case, in a sphere of 20 mm. The errors in marker position could be reduced with a reconstruction using at least three cameras.

CONCLUSION: This algorithm is efficient for the analysis of human movement on horizontal ground. It allows the calculation of spatio-temporal parameters related to the performance in ecological environments over many cycles for walking and many sports (e.g. running)

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