ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering

HUMAN MULTIBODY MODEL FOR THE KINEMATICS IDENTIFICATION OF THE HURDLES RACE USING EULER ROTATION

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Abstract The paper presents some results of athlete crossing over hurdle kinematics. Applying modified Euler and Cardan rotations, in order to positioning the sportsman left towed foot, are obtained the angular positions, speeds and accelerations, as the pictures of the movement sequences.

1. INTRODUCTION

We present bellow some results of applying modified Euler rotation in order to positioning the sportsman left towed foot. Segment positions matrix is named by ? , despite the name ? e in [3]. The first two matrix rows are identically of them of matrix ? in [3]. The rows 4 – 6 associated to rotation RE(f) used to positioning the left towed foot are different. It is possible to use two modified Euler rotations $RE^1(f)$ and $RE^2(f)$:

$$RE^{1}(f) \text{ ? } RY(f_1) \text{?} RX(f_2) \text{?} RY(f_0)$$

$$RE^{2}(f) \text{ ? } RY(f_1) \text{?} RZ(f_2) \text{?} RY(f_0)$$

The second representation seems to be more natural to the athlete motion .

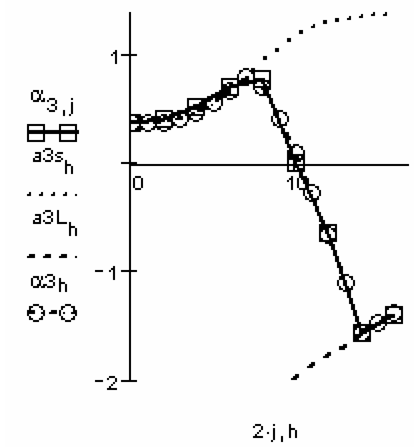
$$\text{? e ??} \begin{bmatrix} \text{?}90 & \text{?}95 & \text{?}110 & \text{?}105 & \text{?}90 & \text{?}85 & \text{?}40 & \text{?}10 & 13 \\ 35 & \text{?}5 & \text{?}45 & \text{?}80 & \text{?}80 & \text{?}75 & \text{?}30 & \text{?}10 & 15 \\ 21 & 24 & 30 & 45 & 60 & 70 & 49 & 10 & 15 \\ 21 & 24 & 30 & 40 & 45 & 0 & \text{?}37 & \text{?}90 & \text{?}80 \\ 9 & 9 & 0 & 5 & 40 & 85 & 58 & 0 & 0 \\ 0 & 0 & 0 & \text{?}5 & \text{?}35 & \text{?}40 & \text{?}25 & 0 & 0 \\ 21 & 24 & 30 & 54 & 110 & 170 & 120 & 70 & \text{?}10 \end{bmatrix} \text{?rd}$$

2. NEW APPROXIMATES

Using the Vibe dual law [3], it is possible to obtain the new approximates.

2.1 Angular positions

In order to estimate the angular position of the thigh, in the third row of matrix ? , it was necessary to introduce a linear segment.



$$a3s_h \; ? \; f\left(\frac{h}{M}, 2\right) ? \; ? _{3,0} \qquad a3_h \; ? \; \frac{(h \; ? \; M)\,(M \; ? \; h)}{58} \; ? \; 2.6$$

$$a3L_h \; ? \; ? _{3,7} \; ? \; 9 \; (? _{3,8} \; ? \; ? _{3,7}) \frac{h \; ? \; 14}{M}$$

$$as3_h \; ? \; \text{if}(h \; ? \; 8, a3s_h, a3_h) \qquad ? 3_h \; ? \; \text{if}(h \; ? \; 14, as3_h, a3L_h)$$

$$DV_1 \; ? \; m^{?1} \sum_j (\, ? 3_{2j} \; ? \; ? _{3,j}\,)^2 \qquad DV^T \, 10^3 \; ? \; ?3.542 \quad 2.487?$$

Fig. 1 The approximation of the third row of matrix

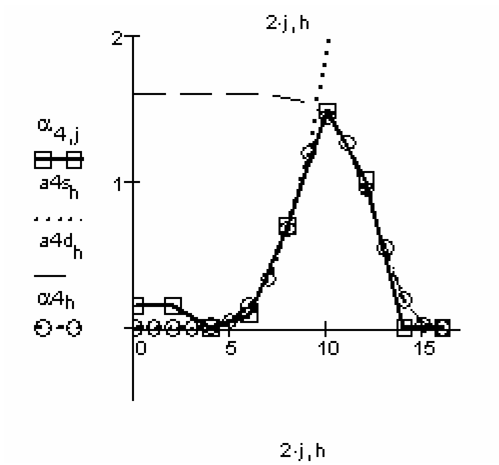


Fig. 2 The approximation of the forth row of matrix

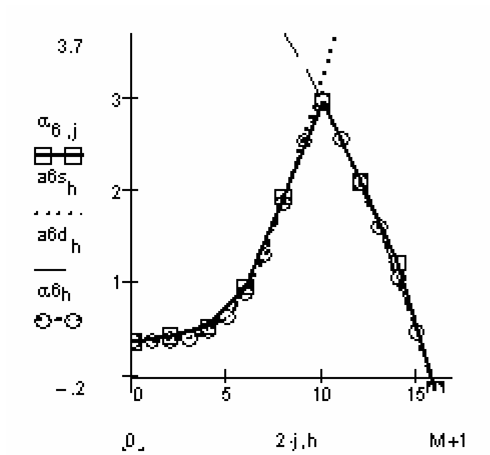


Fig. 3 The approximation of the sixth row of matrix

2.2 Angular speeds

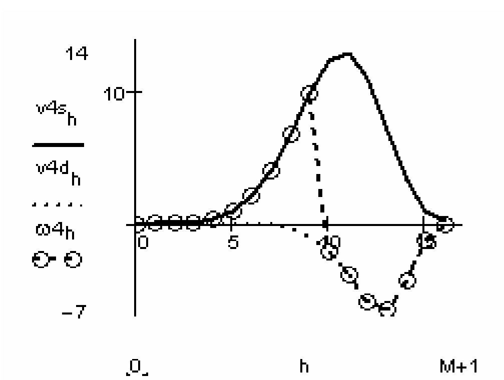


Fig. 4 Component of thigh angular speed in local system $? _4 \; ? \; ? _4$

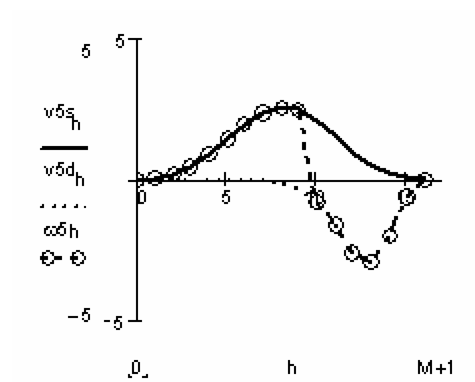


Fig. 5 Component of shank angular speed in knee $? _5 \; ? \; ? _5$

1.3. Angular accelerations

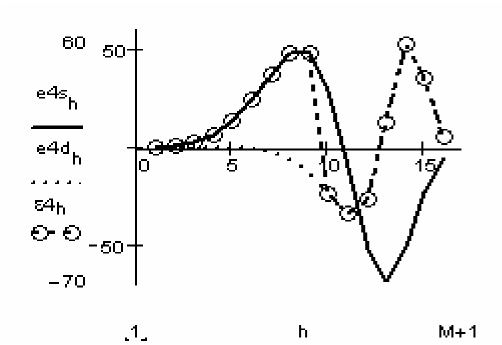


Fig. 6. Component of shank angular acceleration in knee ?$_4$? ?$_4$

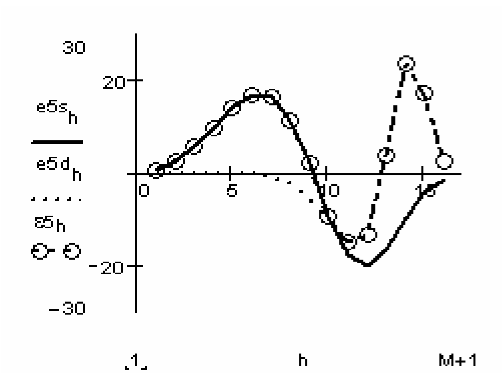


Fig. 7 Component of shank angular acceleration in knee ?$_5$? ?$_5$

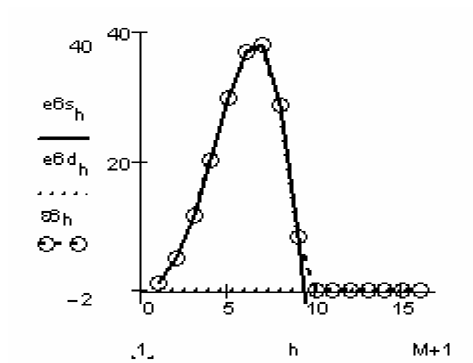


Fig. 8 Component of shank angular acceleration in knee ?$_6$? ?$_6$

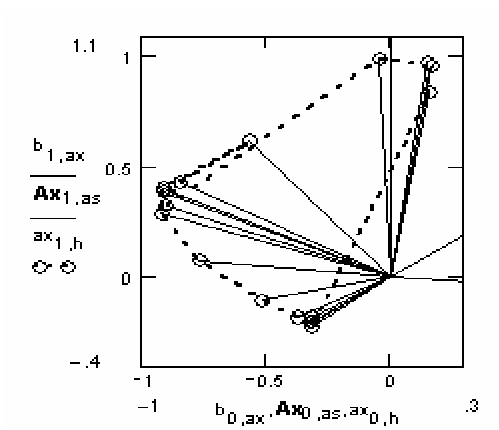


Fig. 9 Instantaneous axis for thigh - Euler

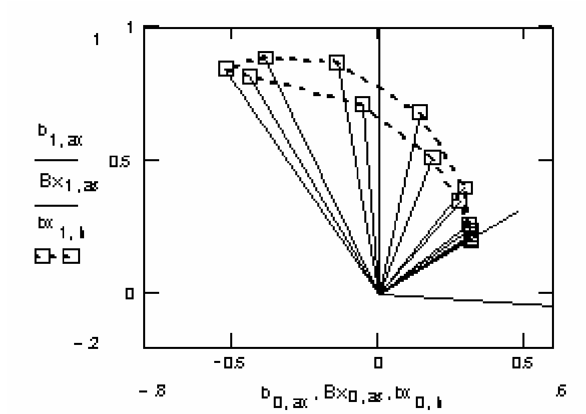


Fig. 10 Instantaneous axis for knee - Euler

Instantaneous finite rotation axis between two successive positions of left towed foot segments describe ruled surfaces, polodical cones in local system. We named by **Ax** the thigh joint axis and by **Bx** the knee joint axis

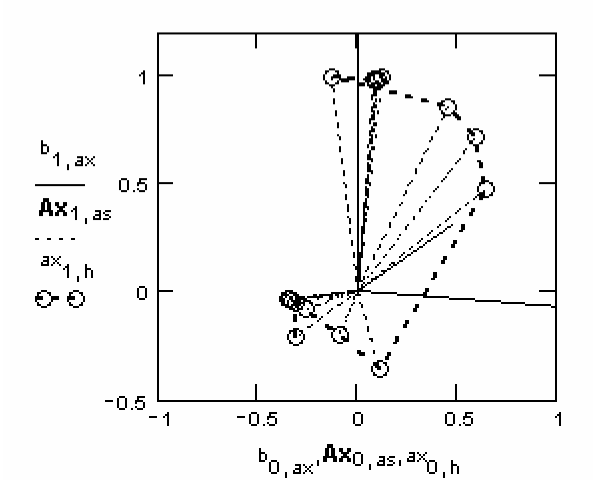


Fig. 11 Instantaneous axis for thigh - Cardan

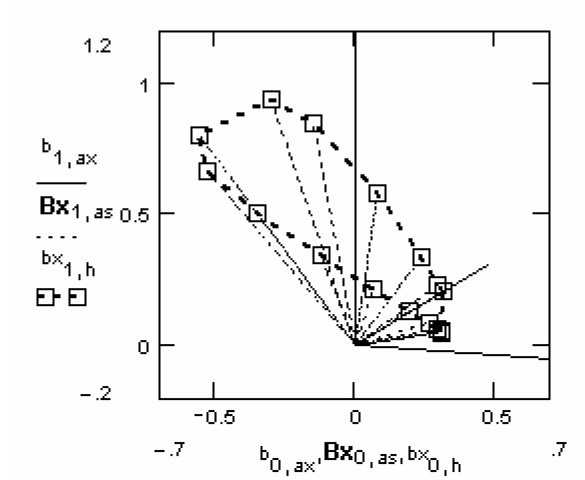


Fig. 12 Instantaneous axis for knee - Cardan

For the two representations, Euler and Cardan, the finite rotation angles between two successive positions of athlete and the angular rotation speeds round Rodriques axis are similar, respectively.

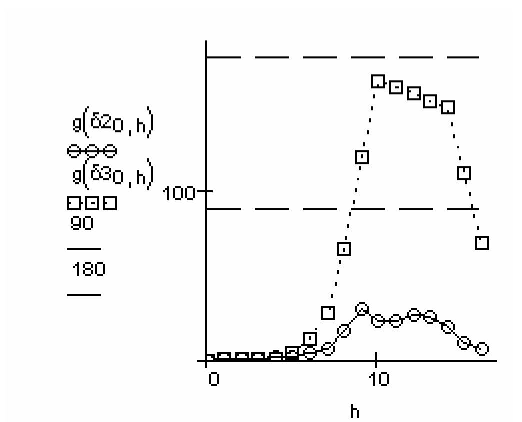


Fig.13 Thigh and shank angular positions - Euler

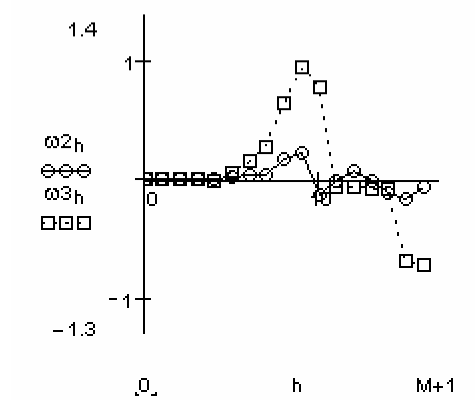


Fig.14 Thigh and shank angular speed - Euler

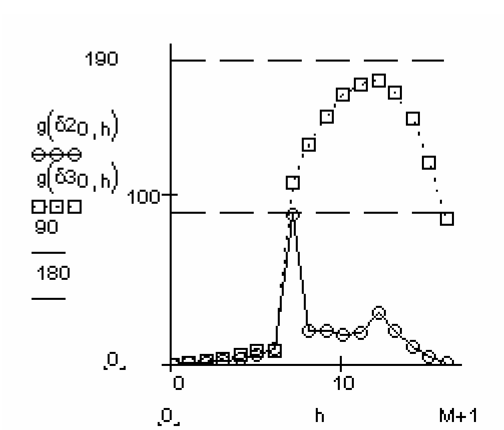


Fig.15 Thigh and shank angular positions - Cardan

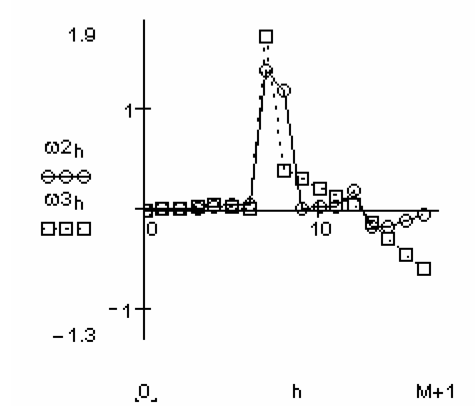


Fig.16 Thigh and shank angular speed - Cardan

Finally, the two pictures extended to a double number of positions in order to join them are similar. In fig.17 are presented the extended picture by interpolation for the left foot positions using Cardan rotations. Below one can see upper, fig.18. and frontal position H = 10 of crossing over hurtle., fig. 19.

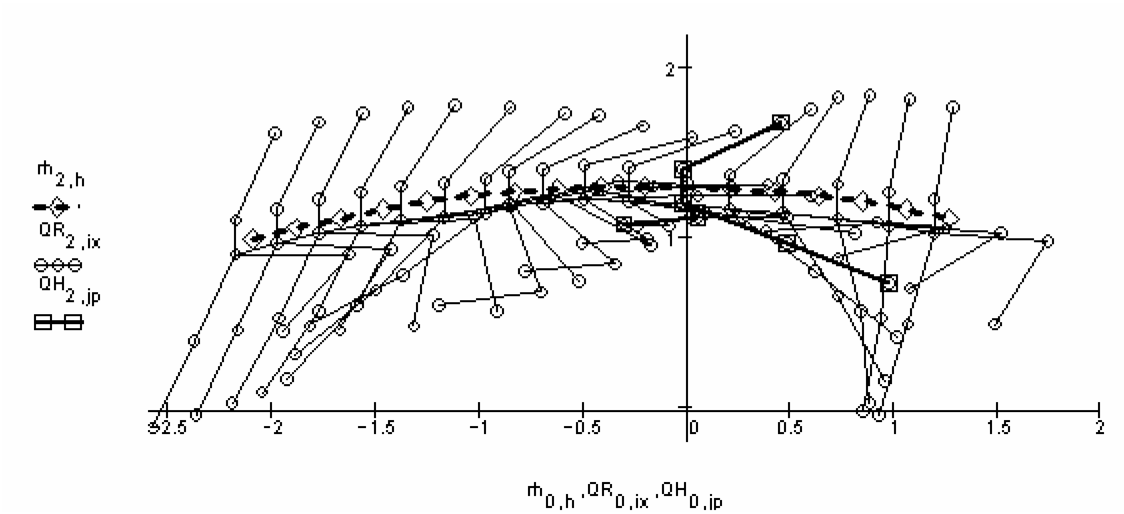


Fig. 17 Extended sequential picture. Cardan rotations.

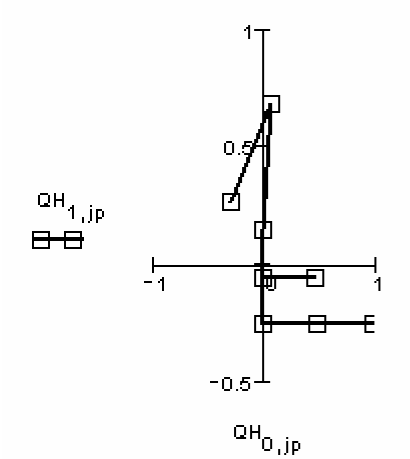


Fig. 18 Upper position

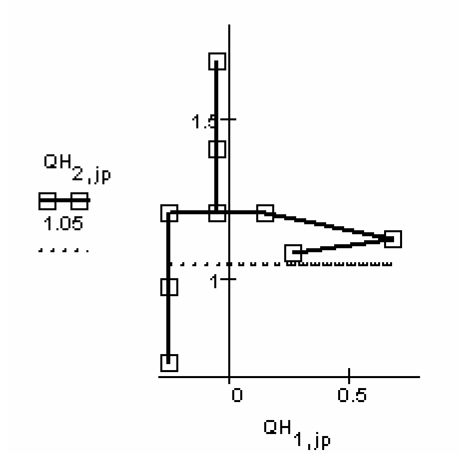


Fig. 19 Frontal position

4. CONCLUSIONS

Surveying all speed and acceleration evolutions in athlete joints, one can observe the rapid evolution in these articulations. The speed direction change is very rapid and the accelerations very high.

In fig.20 are presented the extended picture by interpolation for the left foot positions using Euler rotations. Below one can see upper and frontal position H = 10 of crossing over hurtle.

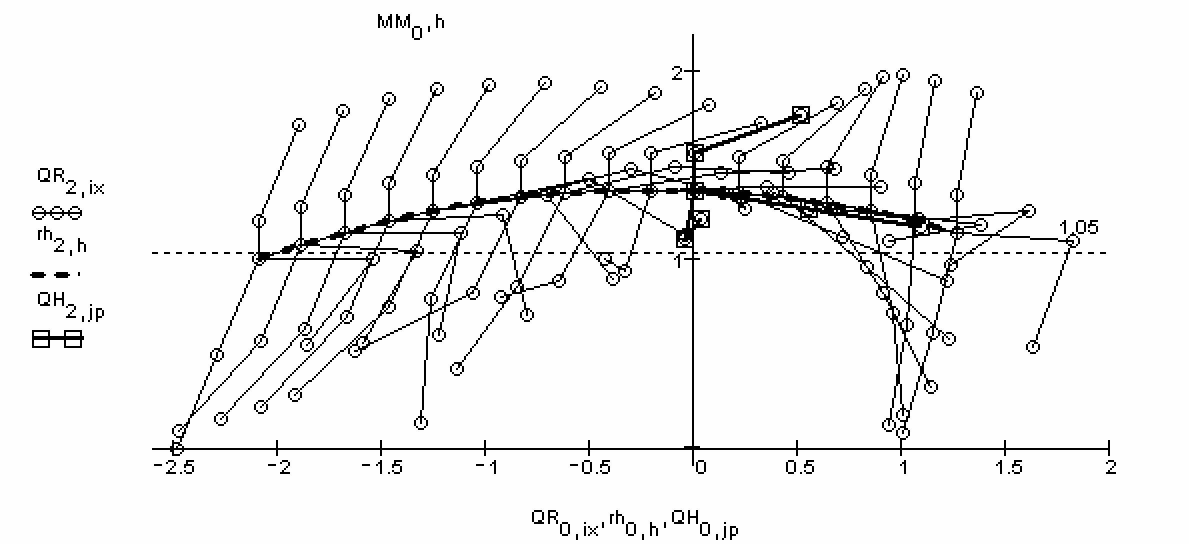


Fig. 20 Extended picture. Euler rotations.

The kinematics in athlete biomechanical joints is much different from a pendulum one in gravity field, or from technical joints. The speed direction change in biomechanical joint is much savage.

This represents a way of athlete psychological behavior in order to cross over hurtle, to prevent the soil touch and to continue the race after the first soil contact of attack foot. On the other way, this permits to choose Vibe dual laws for positional approximation.

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