6TH INTERNATIONAL CONFERENCE ON ELECTROMECHANICAL AND POWER SYSTEMS
October 4-6, 2007 - Chişinău, Rep.Moldova

STUDY OF HUMAN JOINT ANGLE USING CENTRE OF MASS "WAVELET" ANALYSIS

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***Abstract* – This study considered that discussion point one mechanical model of the human body (JAGO model). The mechanical JAGO model for human body have associate one mathematical model with all kinematics equation in mono-dimensional rigid links with three links. In this article we will presentation one method for electrical measurement of one human mechanical model-ground reaction.**
The wavelet analysis can be one solution for dynamic study of ground reaction in high (muscle neurological activity) and low frequency (centre of mass movement) situation. This measure will be make using one force measure platform in six free degrease.

***Keywords*:** *JAGO mechanical model, wavelet analysis, high and low frequency of ground reaction dynamics.*

1. INTRODUCTION

The JAGO represent one mechanical and mathematical model of the musculo-skeletal system. This model was represented by a planar three degrees of freedom open kinematic chain.
Information extraction was limited to the flexion-extension function of ankle, knee, and hip during quasi-planar motor tasks.
Starting from plausible first approximation kinematics, other kinematic functions are iteratively generated by an optimization algorithm and corresponding ground reaction loads are calculated through inverse dynamics.
Kinematic coordinates using B-splines and modified by manipulating the control points was representing by MAZZÂ and CAPPOZZO (2004).
The iterative procedure stops and provides the final kinematic and kinetic estimates when a similarity criterion between estimated and measured ground reac-tion components is satisfied.
The model structure was elaborated upon and the algorithm parameters optimized for robustness and accuracy using a benchmark motion in a simulation exercise.
The maximal root mean square difference over time between estimated and benchmark quantities was approximately 1% of the peak to peak value for ground reaction components and intersegmental couples, and 6% for joint angles[1].
The solution proposed in this article evidenced in high and low frequency ground reaction behaviour using force platform in six free degrees[3].

2. PROBLEM DEFINITION

The JAGO model uses a mechanical model of the human body that consists of a planar open kinematic chain made interacts with the environment at a known point where it is subjected to the action of an external reaction force, the line of action of which passes through that point, and a couple. Subject specific inerţial (mass, locationof the centre of mass, mass moment of inerţia) and geometrical parameters are associated with each modelled body segment.In [1] -Mazza and Coppozzo (2004) the three links of the model represented the shanks, the thighs, and the upper part of the body that incorporates the head, the arms, and the trunk (the so-named HAT) (fig. 11). They were joined by cylindrical hinges endowed with mus-cle equivalent rotational actuators, and located at points ap-proximating the ankle, knee, and hip joint centres. The relevant three degrees of freedom were described using the joint angles indicated in fig. 1. With this model, motor acts may be analyzed during which head and upper limbs may be considered to be stationary with respect to a virtually rigid trunk and the ankle joint stationary with respect to the ground (motionless foot). The ground reaction (GR) force and couple vectors were reduced to the stationary ankle joint centre and were represented by the following components: vertical (7) and antero-posterior (X) force components and the medio-lateral (Z) couple vector. component, relative to a laboratory fixed set of axes consistent with the subject's anatomical planes (fig. 1). From now on, the GRs are sup-posed to coincide with the ankle intersegmental loads.
In [1] the mathematical model receives as input the following quantities:

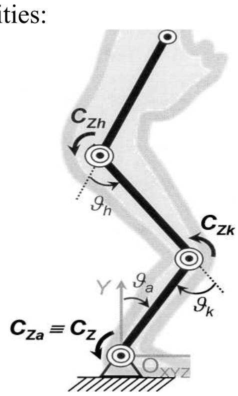
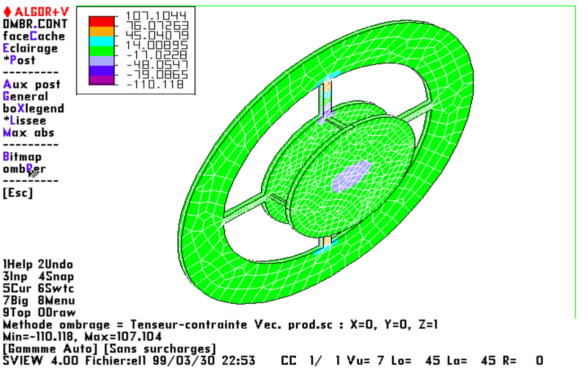
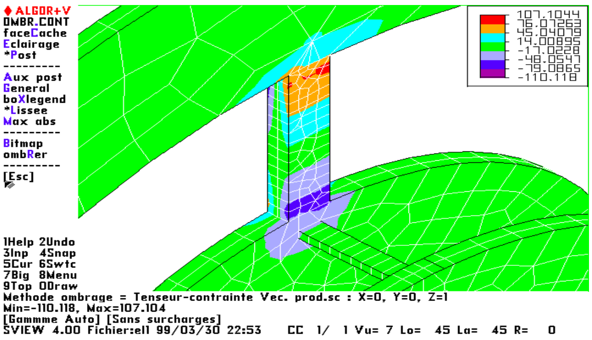


Figure 1

measured pattern versus time of the GR components; measured inițial and final (boundary) values of the ankle,knee, and hip joint angles; expected range ofvariation of the joint angular position,velocity, and acceleration (minimum and maximal values); subject's body segment inerțial and geometric parame-ters as obtained using regression equations and easy tomeasure anthropometric quantities.
We study take into consideration this mathematical model equation and make electric measured dynamic components of ground reaction used wavelet method.
Force platform is construct and modeling for max. 200Kg weighing.
Project of force platform was purpose measurement in six degrees FX,FY,FZ,MX,MY,MZ.
For strain gauge place point determination was used ALGOR programs (finite element method).
This study offer in main measurement electric solution (acquisition data system and digital processing). Value of FX,FY,FZ,MX,MY,MZ vector determination to establish pathologic parameters for human static and dynamic. For unbalance voltage processing is use one instrumental amplifier (with A=1000) AD 623.
This circuit offered eighth CMRR possibility. For strain gauge realization was use 350 Ohm resistive sensors.
This sensor is place in high and linear deformations points. In fig.2 is presents force platform and high deformation place point.





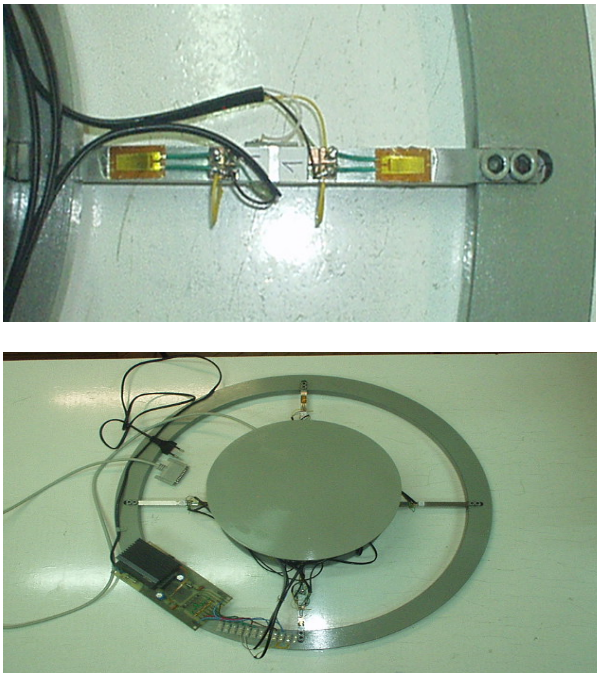


Figure. 2

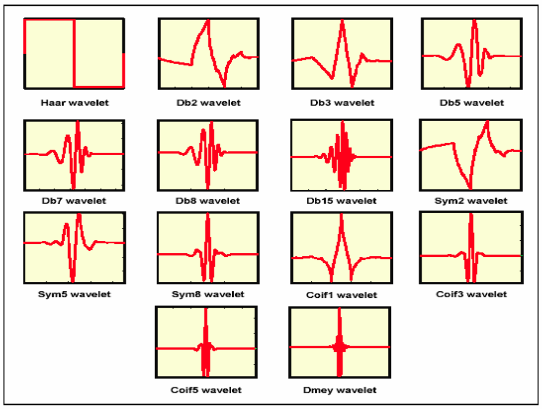
For measure is necessary using one time multiplexing of input channel (MMC4053). Input channel was selected od parallel port through $37A_H$ write register. Read was in 100 points with 10ms time interval

3. METHOD PRINCIPLE

For static components analysis was use “wavelet” analyses. Approximations of “wavelet” analyses to represent static components variations (level and period). Depending on this data was establish one ortostatism state diagnostic (fig.4). Details of “wavelet” analyses to represent neurological state of patient.

Example: F_X signal analysis- OX direction-ground reaction

Step of algorithm:.txt file construction (100 points)
Use “ daubechies2” wavelet achieves one single level of F_X signal



- A1 approximation and D1 details
- Three level signal decompose
- Extract of three level approximation coefficient.
- Extract of three level details coefficient
- Display approximation and details results.

Program:

```
FX1=[1.000 1.000 1.001 1.000 1.000 1.000 1.000
1.000...
1.000 1.000 1.001 1.001 1.000 1.000 1.000 1.001...
1.001 1.000 1.001 1.000 1.000 1.000 1.000 1.000...
1.000 1.000 1.001 1.000 1.000 1.001 1.000 1.001...
1.001 1.000 1.001 1.001 1.000 1.000 1.002 1.000...
1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000...
1.000 1.002 1.001 1.000 1.003 1.000 1.000 1.000...
1.000 1.000 1.001 1.001 1.000 1.000 1.001 1.001...
1.000 1.001 1.001 1.000 1.000 1.000 1.000 1.000...
1.001 1.000 1.000 1.000 1.000 1.000 1.001 1.000...
1.000 1.001 1.001 1.000 1.000 1.000 1.000 1.001...
1.001 1.001 1.001 1.000 1.000 1.000 1.000 1.000]';

plot(FX1); title('Semnalul analizat-forta FX1-')
    [cA1,cD1]=dwt(FX1,'db2');
    A1 = upcoef('a',cA1,'db2');
    D1 = upcoef('d',cD1,'db2');

subplot(1,2,1); plot(A1); title('Aproximarea A1')

subplot(1,2,2); plot(D1); title('Detaliul D1')
[C,L] = wavedec(FX1,3,'db2');
    cA3 = appcoef(C,L,'db2',3);
    cD3 = detcoef(C,L,3);
    cD2 = detcoef(C,L,2);
    cD1 = detcoef(C,L,1);
    A3= wrcoef('a',C,L,'db2',3);
    D1 = wrcoef('d',C,L,'db2',1);
    D2 = wrcoef('d',C,L,'db2',2);
    D3 = wrcoef('d',C,L,'db2',3);

subplot(2,2,1); plot(A3); title('Aproximarea A3')

subplot(2,2,2); plot(D1); title('Detaliul D1')

subplot(2,2,3); plot(D2); title('Detaliul D2')

subplot(2,2,4); plot(D3); title('Detaliul D3')
A0 = waverec(C,L,'db2');

subplot(2,1,1);plot(FX1);title('subiectul1: Semnalul original-forta FX1-');axis off
subplot(2,1,2);plot(A3);title('subiectul1: Nivelul 3 de aproximare-forta FX1-');axis off
subject 1 data:
SEX: F
AGE: 33 yars
WEIGHING: 66,5Kg PATOLOG.: NORMAL
```

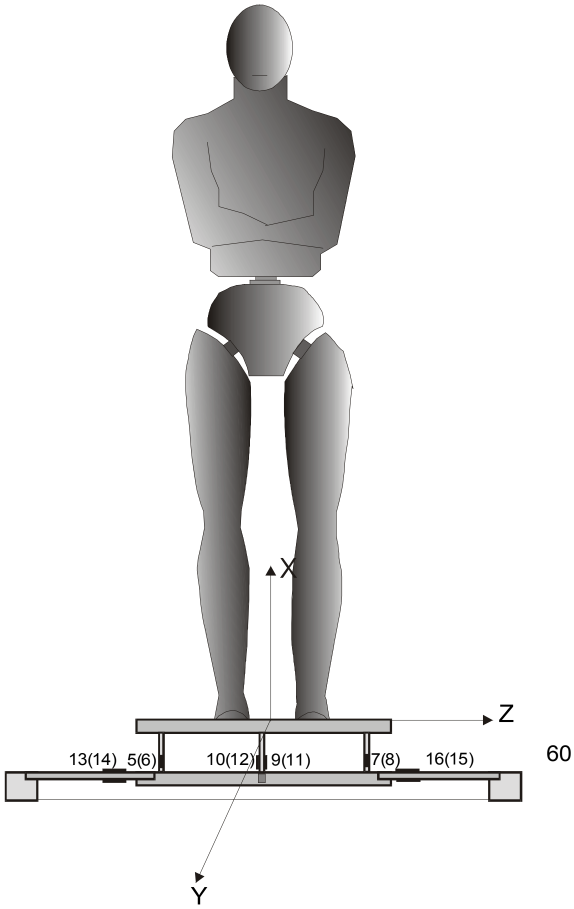


Figure.4

4. RESULTS AND CONCLUSION

Approximation of FX components of ground reaction
- low frequency components for human centre of mass equilibrium

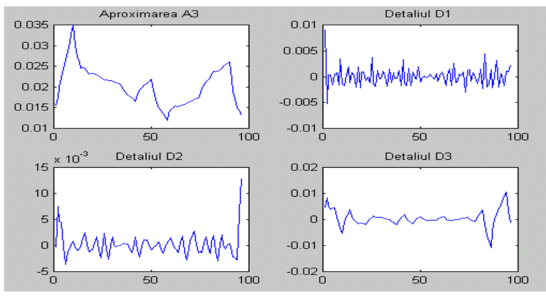


Figure.5

Details of FX
components of ground reaction
- high frequency components for human muscle activity

Original signal FX of ground reaction

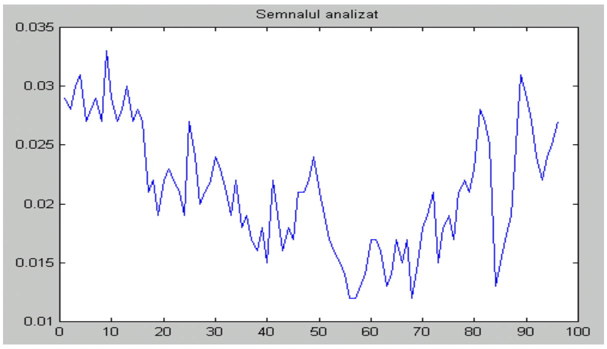


Figure.6

Centre of mass equilibrium and muscle neurogical activity:

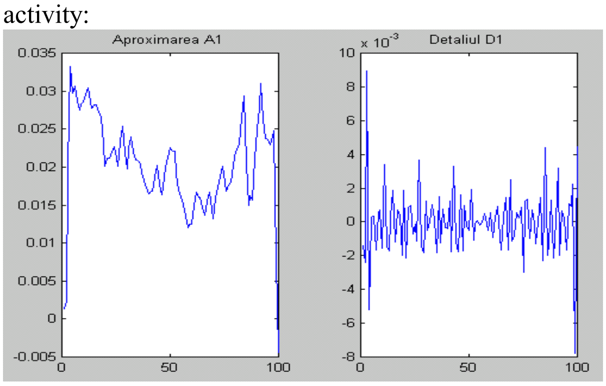


Figure.7

5. ACKNOWLEDGMENTS

This study was included in PhD licence of first author with thema : „ Study of human static and dinamic equilibrium in neurological deseases" U.P. Timisoara 2003.

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