SOME HUMAN UPPER LIMB COMBINED MOTIONS DETERMINATION USING CONTEMPLAS MOTION ANALYSIS EQUIPMENT

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Abstract. In this paper we want to establish the angular amplitudes developed at the human upper limb wrist joint level. For this, two human subjects will be proposed for the experimental tests. One human subject has a healthy forearm and the other has some trauma at the wrist joint level.

The experimental tests will be performed by using special equipment called CONTEMPLAS for Motion analysis. This has two high-speed cameras which enable to analyze combined motions in a 3D space. This experimental research will lead us to create a database in order to elaborate some special orthotic devices for human upper limb motions rehabilitation.

1. Introduction

In present different motion analysis equipments are commercialized on the market from large fields such as industry, scientific research in different domains, human health recovery, etc. In the medicine domain especially kinetotherapy, there are different equipments used for human body rehabilitation such as: SIMI Motion, CONTEMPLAS, Vicon Motion System, BioSyn Systems, etc. [2, 5, 11, 12].

The aim of these motion analysis systems is to determine on experimental way some cinematic parameters in 2D or 3D environments, such as: displacements, velocities, accelerations, etc.

In biomechanics domain, there are many researchers and research centers which their main research activity is to perform cinematic analysis of human segments for different activities. These lead to design or to improve different prosthesis or orthosis types in order to help people which posses disabilities [3, 7, 8, 10].

2. Human Upper Limb Anatomical Considerations

It is necessary to identify the motion possibilities of a human healthy subject while performing some specific manipulation activities of objects having different geometric forms. For this we must achieve a human upper limb structural study from an anatomical viewpoint. In figure 1 we identify the main human upper limb bony elements, which are: 1-clavicle, 2-scapula, 3-humerus, 4-radius, 5-ulna, 6-carpal, 7-metacarpal, 8-phalangs [6].

By taking into account the existent information in the specialty literature, one identifies the motion types achieved by a human upper limb at the elbow and wrist joints level. Thus at the elbow level one can perform two activity types such as: flexion/extension, pronation/supination (figure 2). For the upper limb wrist joint other motions are achieved: flexion/extension, adduction/abduction (figure 2). The angular amplitudes specified in specialty literature [1, 6, 9], for human elbow and wrist joints are shown in table 1.

Table 1.

Motion	Average (deg)	Angular amplitude
Wrist flexion/extension	85^0 – 0 - 75°	155°- 160^0
Wrist abduction/adduction	20^0 – 0 – 35°	50°- 55°
Elbow pronation/supination	90^0 – 0 - 70°	150°- 160°
Elbow flexion	0- 142^0	135°- 142°

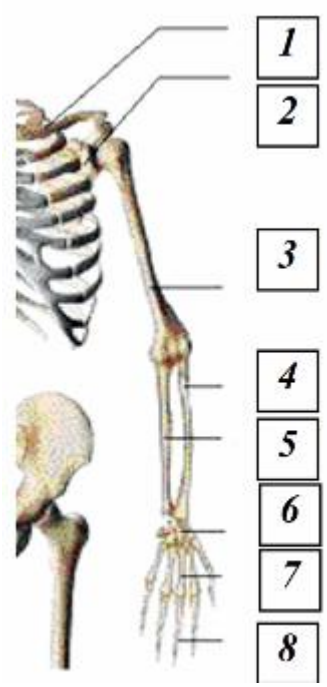

Figure 1: Human upper limb main bones

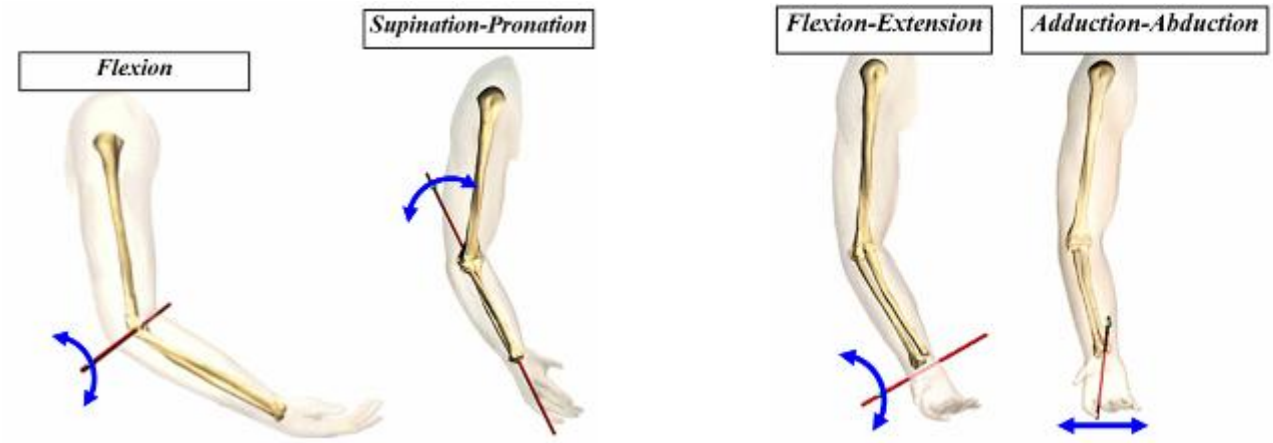

Figure 2. Human upper limb motion developed at the elbow and wrist joints

3. Human upper limb motion analysis by using CONTEMPLAS equipment

Taking into account the experimental research aim, the motions developed by the human upper limb for both subjects presented here will be evaluated experimentally by using motion analysis equipment, which is called CONTEMPLAS.

Two human subjects were proposed for these experimental tests, and have the same human forearm sizes. One is a healthy subject, and the other has a bony trauma at the wrist joint level (figure 3).

a. ***b.***

Figure 3. The human subjects hand proposed for this experiment. a- the trauma hand; b-the healthy hand.

The CONTEMPLAS equipment has two high speed cameras for capturing and recording sequences and a DELL notebook for sequences analysis in real time with Templo Standard module software [2]. University of Craiova-Faculty of Mechanics owns this special equipment, which is used for this experimental research presented in figure 4. The high-speed cameras are CCD-Chip 2.1.0 type.

This equipment enables us to determine the desired points trajectories and spatial angular variations onto either mechanical or biomechanical mobile systems through successive identifications of the joint centers positions in their structures.

CONTEMPLAS Motion analysis general procedure for experimental determinations is shown in figure 5.

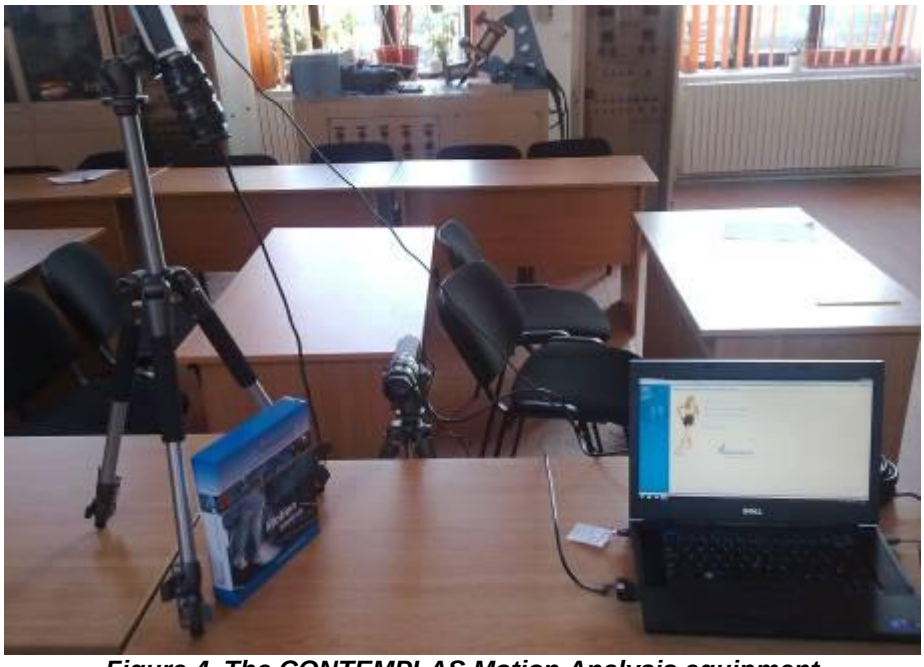

Figure 4. The CONTEMPLAS Motion Analysis equipment

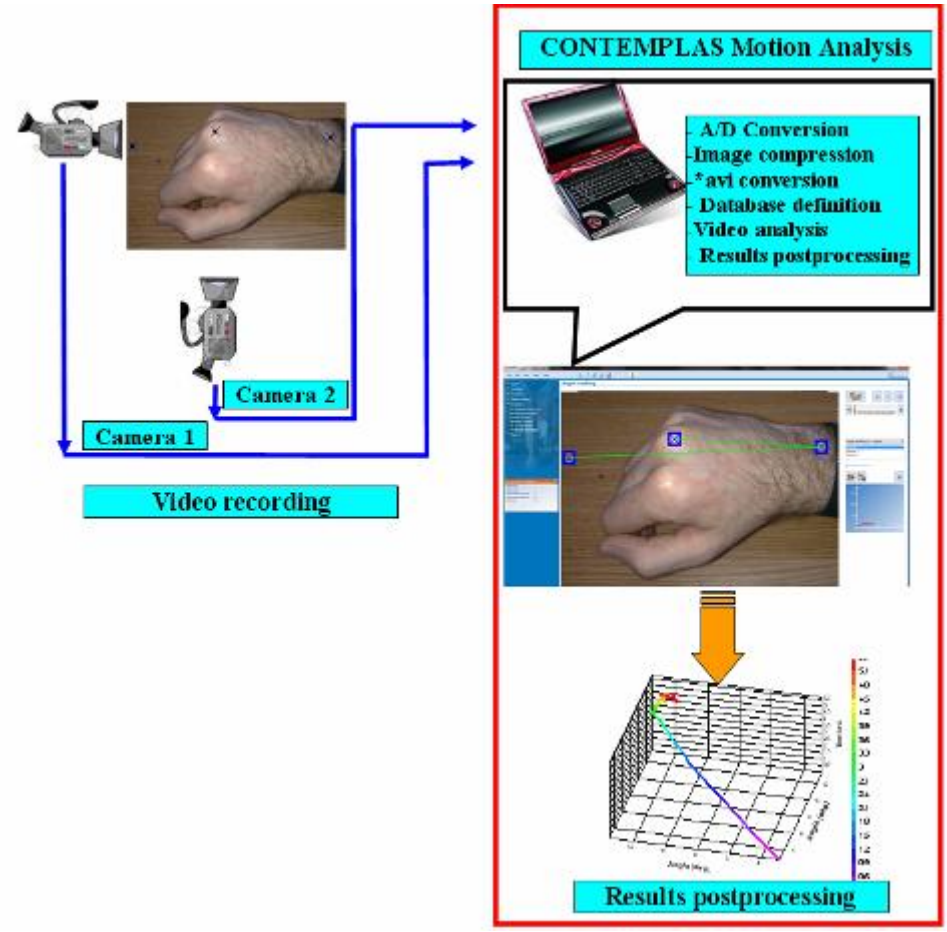

Figure 5. CONTEMPLAS Motion Analysis general procedure scheme

Thus, one attached markers in the rotation joints centers with a view to determining the angular amplitude developed by the human forearm for both human subjects at the wrist joint level. A sequences series of the experimental analysis using this equipment is shown in figures 6, 7, 8 and 9. In these sequences the forearm for both human subjects will perform combined flexion/extension and abduction/adduction motions.

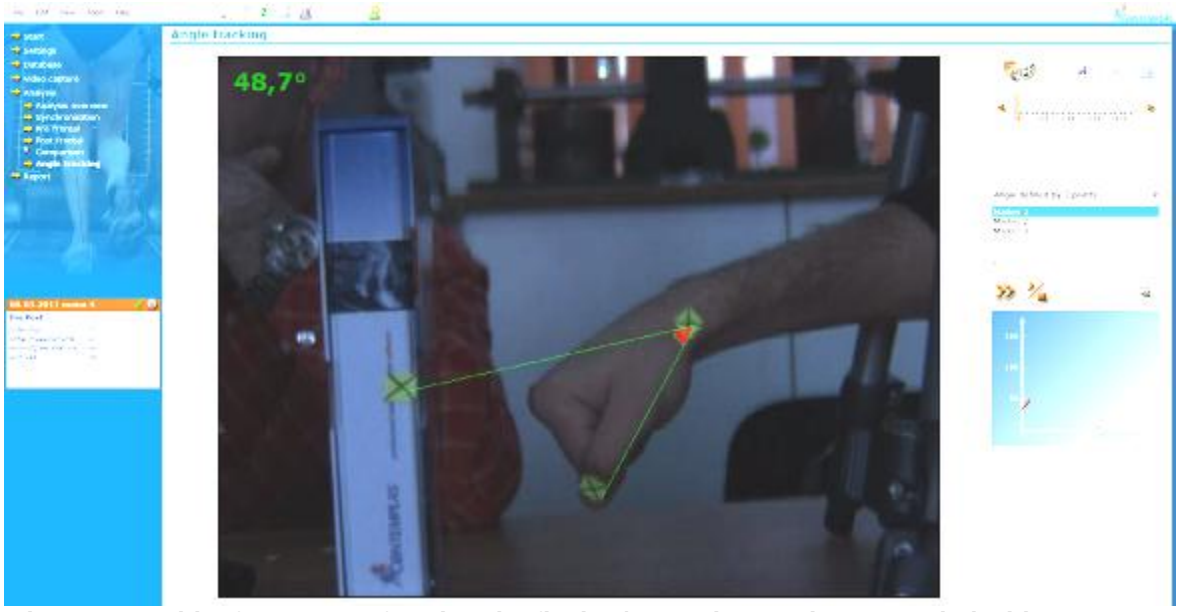

Figure 6. Healthy forearm performing the flexion/extension motion, recorded with Camera 1.

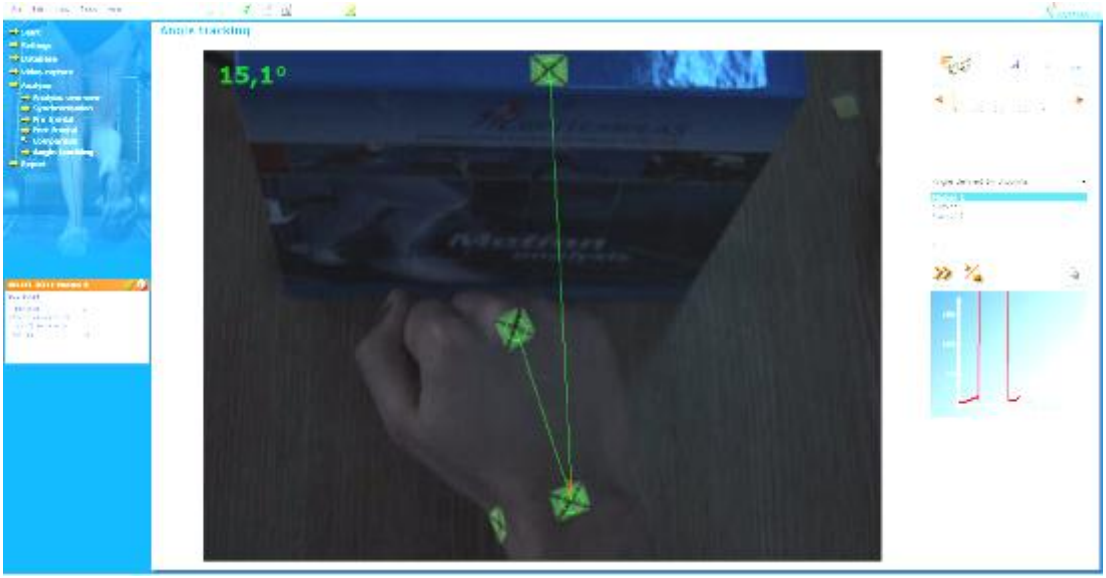

Figure 7. Healthy forearm performing the abduction/adduction motion, recorded with Camera 2.

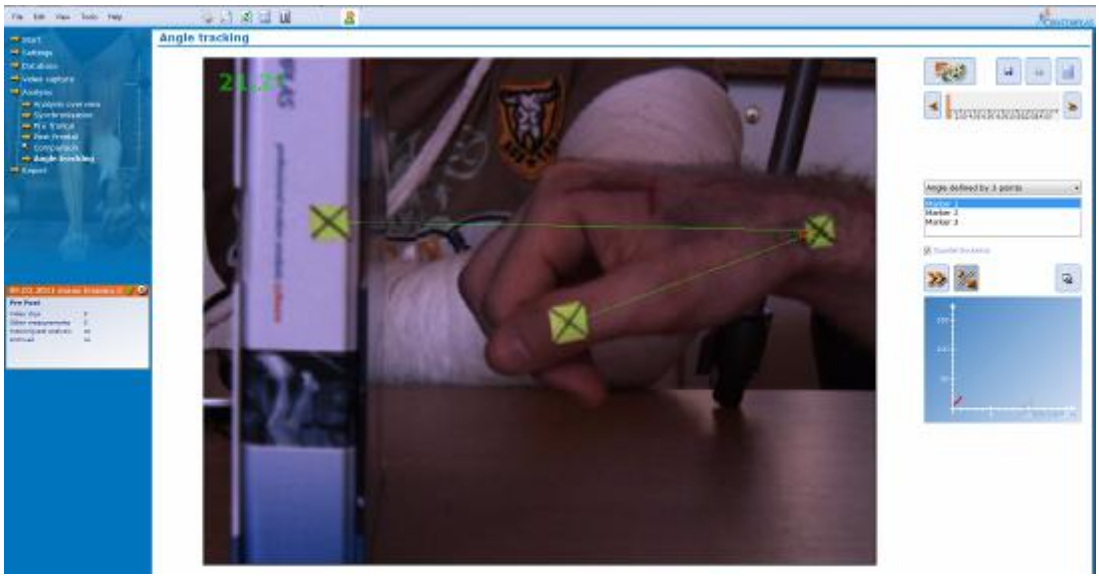

Figure 8. Traumatized forearm performing the flexion/extension motion, recorded with Camera 1.

Figure 9. Traumatized forearm performing the abduction/adduction motion, recorded with Camera 2.

4. Conclusions

The experimental research results are presented in the diagrams from figures 10 and 11. In these diagrams the angular amplitudes depending on time when motion was performed are shown.

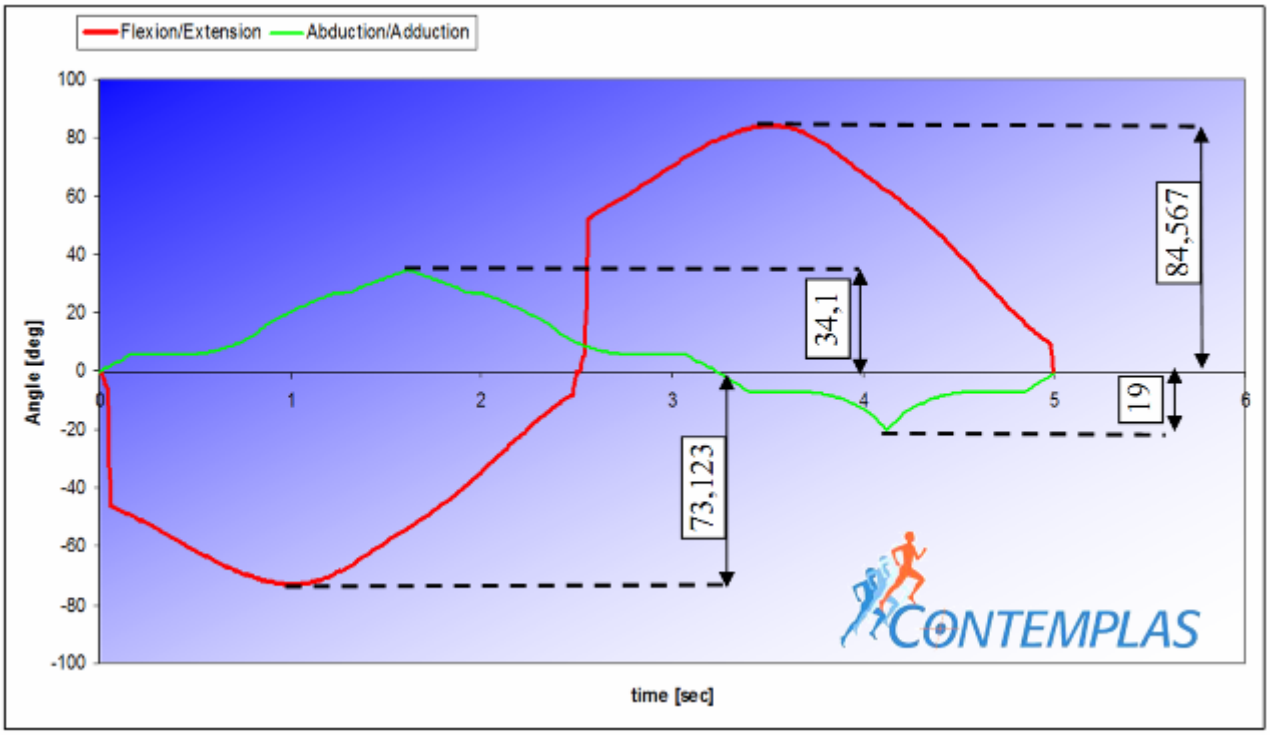

Figure 10. Healthy forearm angular amplitude for flexion/extension and abduction/adduction

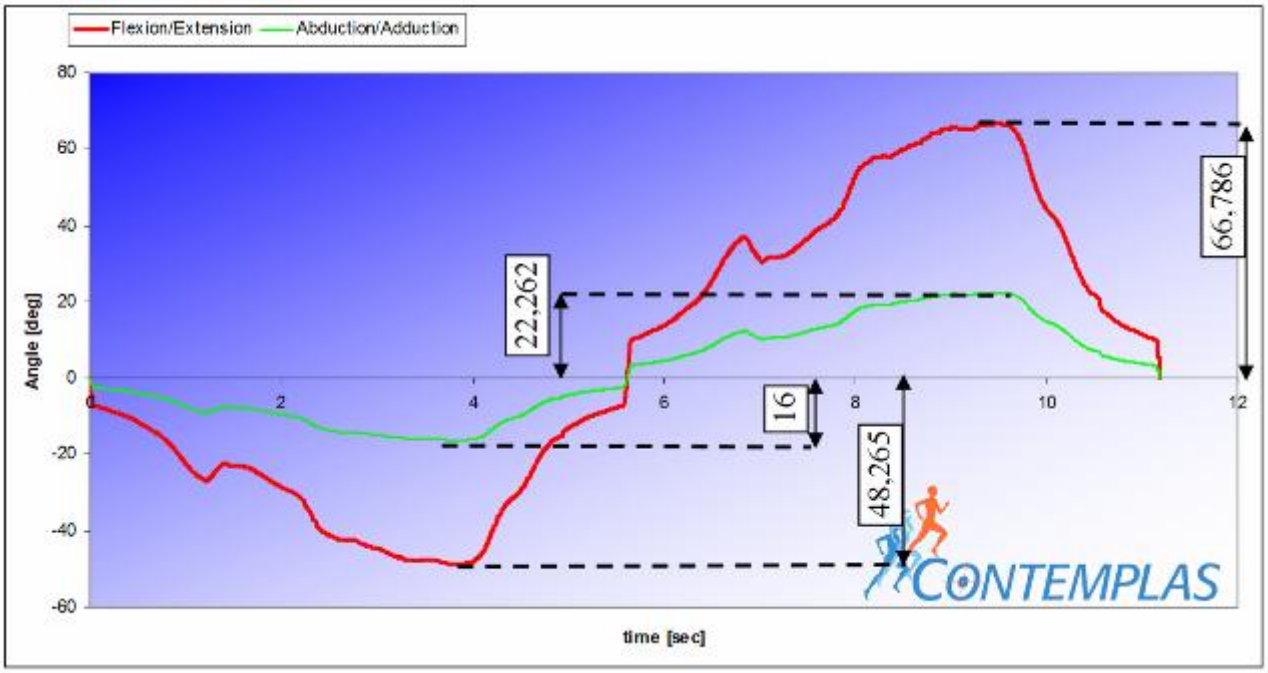

Figure 11. Traumatized forearm angular amplitude for flexion/extension and abduction/adduction

By analyzing the diagram from figure 10 in accordance with the results existing in specialty literature, one conclude that:

- the angular amplitude developed by the healthy forearm for flexion\extension motion is 157,69 and the limit specified in Table 1 is 155...160 degrees;
- for abduction/adduction the angular amplitude developed by the healthy forearm motion is 53,1 and the limit specified in Table 1 is 50...55 degrees.

Through this experimental research one validate the results for healthy forearm and it can consider these results for serving as a template motions;

By analyzing the diagram from figure 11 in accordance with the results from figure 10, we conclude that:

- the angular amplitude developed by the traumatized forearm for flexion\extension motion is 115,051;
- for abduction/adduction the angular amplitude developed by the traumatized forearm motion is 38,262.

Through this analysis, the traumatized forearm need a special therapy programs to follow, in order to improve the flexion/extension and adduction/abduction motions developed at the wrist joint level.

By using this special equipment we can observe the angular amplitude values are different in some areas of the diagrams shown in figures 10 and 11. In figure 11, one observes that the motions evolution are in steps, this explain the pain symptoms that prevent continuous motions. This means that the motions can be improved by implementing some recovery procedures in order to develop some motion segments in the diagram critical areas exposed in figure 11.

The CONTEMPLAS equipment can be used for other mobile systems which develop spatial and planar movements in different domains, such as industry fields (e.g. Industrial robots), biomechanics, medicine, sports, etc.

5. Acknowledgements

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6. References

[1] Buzescu Al., Scurtu L. Anatomie si biomecanica. Editura A.N. E.F.S. 1999.
[2] CONTEMPLAS Motion Analysis Technical data Manual 2010.
[3] Copiluşi C. Cercetări privind sisteme mecanice aplicabile în medicină. PhD. Thesis. Craiova, 2009.
[4] Copilusi C., Dumitru N., Ciocan P. Motion laws determination, on experimental way, of joints from the human lower limb structure for certain activities imposed to the locomotor apparatus. Annual Session Of Scientific Papers IMT Oradea 2008.
[5] Functional Assessment Of Biomechanics System - User Manual. 2009. www.biosynsystems.net
[6] McCracken T. Nou atlas de anatomie umană. Editura Aquilla. 2009.
[7] M. Goffredo, I. Bernabucci, M. Schmid, S. Conforto, T. D'Alessio, TwinN-FES: Tracking with Neural Network to assist and restore upper arm movements through smart Functional Electrical Stimulation in hemiplegia. International Workshop on Biosignal Processing and Classification (BPC 2006), Portugal, 2006.
[8] Kurtzer Isaac, J. Andrew Pruszynski, Stephen H. Scott. Long-Latency Responses During Reaching Account for the Mechanical Interaction Between the Shoulder and Elbow Joints. Journal of Neurophysiology. 2009
[9] Nenciu G. Biomecanica în educaţie fizică şi sport. Aspecte generale., Universitatea Spiru Haret, Editura Fundaţia România de Mâine, Bucureşti, 2005.
[10] P. Caselli, M. Goffredo, I. Bernabucci, M. Schmid, A study for a combined analysis of planar arm movements, SIAMOC 2005.
[11] SIMI Motion User Manual 2004. http://www.simi.com
[12] VICON MX System Manual 2008. http://www.vicon.com/products/viconmx.