A low-cost system for the biomechanical analysis of tennis players

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Abstract

This paper presents a low-cost system for the biomechanical analysis of tennis players. This platform consists of three main components: a biomechanical model of the upper limb for tennis players, specifically of the shoulder, elbow and wrist joints, developed in OpenSim; an Arduino platform, which performs the collection of data associated with the movement executed by the tennis players, through a set of sensors placed on the frame of the tennis racket and elastic bands placed on the elbow and wrist joints, to perform the direct measure of the movement angles; and finally, a graphical user interface developed in LabVIEW platform to visualize the biomechanical parameters under analysis.

Keywords. Biomechanics, sport, tennis, modeling, visualization, data acquisition and synchronization, instrumentation and control.

1. Introduction

In the last years, several researcher groups have developed and implemented methodologies and systems for biomechanical analysis of athletes in sports activities with the aim of improving their athletic performance, as well as reducing the risk of injuries. Particularly focus has been given to the analysis of racket vibrations and shock transmission to the wrist, elbow and shoulder during the movements performed by tennis and badminton players (Rogowski 2015).

The present work describes a low-cost system for the biomechanical analysis of tennis players.

2. Hardware and Software

The developed system includes three main components: 1) a biomechanical model of the upper limb for tennis players, specifically of the shoulder, elbow and wrist joints, developed in OpenSim; 2) an Arduino platform, that performs the collection of data associated with the movements executed by the tennis player, through a set of sensors placed on the frame of the tennis racket, in order to obtain the linear an angular accelerations of the racket, a force sensor to obtain the tightening force exerted by the hand to grip the racket, and elastic bands placed on the elbow and wrist joints, in order to directly measure the movement angles, two electromyography sensors (EMG) used to assess the electrical activity of the Biceps and Triceps muscles; and finally, 3) a graphical user interface developed in LabVIEW in order to visualize the biomechanical parameters under analysis. The data acquisition is obtained in real time and the signals are synchronized by a real-time clock (RTC) (Gomes 2015).

The developed biomechanical model of the upper limb consists of 32 bones, 30 junctions and 38 muscles, which are involved in the movements under analysis. The tennis racket is considered as being an additional body segment, with the adequate inertial and elastic characteristics (Gomes 2015, 2015a).

The interface of the developed system consists of various menus organized by tabs, which allow the easy visualization of the biomechanical parameters under analysis. Figure 1 shows the low-cost system developed for the biomechanical analysis of tennis players. In this figure, one can see also a detail of the monitoring window concerning the wrist movements: radial/ulnar deviation and flexion/extension (Gomes 2015b).

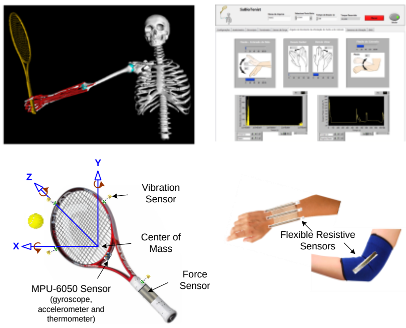

Figure 1: Components of the low-cost system developed for the biomechanical analysis of tennis players.

Figure 2 shows an example of the active force values obtained regarding the muscles of the wrist joint during a tennis serve.

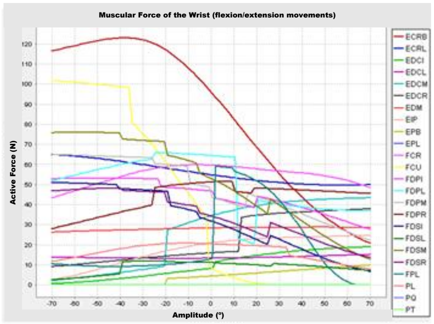

Figure 2: Active muscular force of the wrist movements during the execution of a tennis serve.

3. Conclusions

The system developed intends to be a helpful low-cost tool for researchers and players in order to improve their tennis performance and avoid injuries.

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