THE KNEE PROSTHESIS SIMULATOR CONTROL SYSTEMS FOR THE COUNTINUOUS STATIC BALANCE

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Introduction

The kinematic study of joint surfaces and contact mechanisms are of great importance for the diagnosis and treatment of joints' afflictions, for judicious design of joint prostheses and in studies concerning the stability and deterioration of the joint due to wear on the artificial joints or degeneration of the cartilage of natural joints [Taylor, 2001 and Tomaso, 2004]. The paper presents a a control system for knee prosthesis simulator (KPS), on 5 degrees of freedom which maintains a constant force of vertical pressure on the tibial component using magnetorheological devices (MRD) for the continuous static balance (CSB). The control system has 4 knee prosthesis simulator stations. Each station allows, individually or jointly with the others, the Cartesian force and torque (Fx, Fy, Fz, Mx, My, Mz) to be monitored continuously or at periodical intervals using load cells [Capitanu et al, 2008].

Methods

First considered is a mathematical model determined off-line, from which the trajectories for femoral and tibial movement are generated online. The trajectory of the tibial movement is controlled in real time by the KPS hybrid force-position control system (fig.1). Moreover, a semi-active equilibrium system has been conceived in which the static damping device is replaced with a magneto-rheological dissipater, controlled by the open architecture system presented in Figure 1. In the teach-in phase, the forces appearing in the joints in a complete loop of the auctioning mechanism are stored. In the real time control phase, these values are used as inputs for the movement modeling block, which processes the equations for the KPS mechanism equilibrium, thereby determining the reference signal for MRD control. Through comparison with the reaction force F_R in the joint in a PID control loop, the control current i_{LMR} for the MRD is solved, respectively the control error ε_{LMR}, with the aim of achieving the compensation force F_{CSB} needed for continuous static equilibrium. The parameters θ_i, θ_r, f_i, f_r, ε_r, are specific to hybrid position – force control [Capitanu and Vladareanu, 2008].

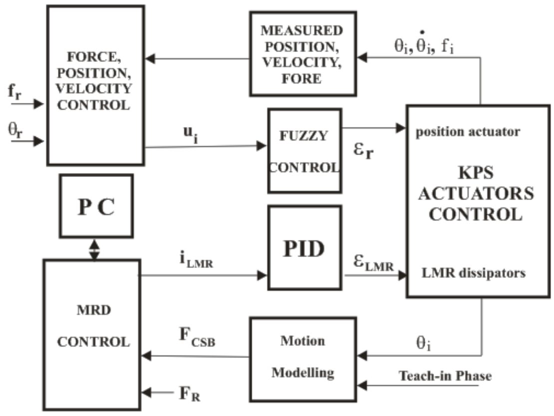

Figure 1: The KPS hybrid force-position control system using magneto-rheological devices

Results and Discussion

The high reliability of the KPS is obtained by using PLCs systems in Open Architecture structure. The applications have concluded that fatigue wear is the main phenomenon responsible for massive wear of the polyethylene insert and the maximum wear probably starts inside the insert under the contact area which concurs with the severe delaminating. Using MR devices for continuous static balance has led to improving the accuracy of measurements in the analysis on wear phenomenon of the total knee prosthesis.

References

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