Modeling and simulating the dynamics of the grand piano action

A. Thorin[a], X. Boutillon[a], J. Lozada[b] and X. Merlhiot[c]
[a]CNRS - École Polytechnique, Lab. de Mécanique des Solides, École Polytechnique, F-91128 Palaiseau Cedex, France
[b]CEA LIST, Sensorial and Ambient Interfaces, F-91191 Gif-Sur-Yvette Cedex, France
[c]CEA LIST - LSI, CEA SACLAY - DIGITEO MOULON, Point courrier 178, F-91191 Gif Sur Yvette Cedex, France
boutillon@lms.polytechnique.fr

ISMA2014/139
Modeling and simulating the dynamics of the grand piano action

A. Thorin[a], X. Boutillon[a], J. Lozada[b] and X. Merlhiot[c]
[a]CNRS - École Polytechnique, Lab. de Mécanique des Solides, École Polytechnique, F-91128 Palaiseau Cedex, France
[b]CEA LIST, Sensorial and Ambient Interfaces, F-91191 Gif-Sur-Yvette Cedex, France
[c]CEA LIST - LSI, CEA SACLAY - DIGITEO MOULON, Point courrier 178, F-91191 Gif Sur Yvette Cedex, France
boutillon@lms.polytechnique.fr

The grand piano action has been developed empirically over two centuries. In its modern version, it provides a remarkably accurate control of the hammer velocity and its impact time. By means of an elementary 1-DOF model, we show why it is mostly preferable to consider and simulate the dynamics by computing the reaction force in response to a motion imposed by the finger rather than the opposite. We present a complete dynamical model based on that proposed earlier by Lozada: 6 rotating bodies (key, damper, whippen, jack, escapement lever, hammer), pivots subject to dry and viscous friction, 13 contact zones with reacting and dissipative forces, 3 of them (hammer-jack, jack-escapement button, hammer-check) being also subject to Coulomb friction. This model introduces discontinuities on the velocities. The problems raised by the usual regular-dynamics formulation are discussed and a non-smooth dynamics approach is proposed. The results of the numerical simulation of the model are in very good agreement with the measurements for levels of playing ranging from *piano* to *forte*.