Abstract

Due to the rapid evolution in computational technology, physics-based sound synthesis is becoming more and more popular. It aims to develop a discrete-time system based on the instrument's physics, that can reproduce the characteristic sounds of the instrument. The state of the art on the physics-based sound synthesis of cymbals is still far away from industrial applications, however, based on the available sound samples the progress is encouraging: the various sound effects of cymbals (like pitch glides and crashes) can be sufficiently reproduced. However, the overall sound is still heavily artificial.

Though the cymbal seems to be a simpler instrument than eg., the piano or the violin, simulating it properly is a difficult task. The characteristic sound of cymbals is based on strong nonlinear effects thus numerical methods are inevitable. One can find finite difference methods and modal approaches in the literature. The finite element method, with the aim of sound synthesis, has not been directly applied, however, some of the modal approaches are based on finite element modal solutions of the linear problem. In this Thesis, the finite element method is applied to the nonlinear vibration problem to generate sound. To begin with, the finite element theory is presented and applied to the wave equation. The time-domain solution is generated with the finite difference method, and its stability is analyzed. In the next step, the finite element discretization of the Kirchhoff linear plate is presented using the Morley and the Argyris elements. Efficient and general algorithms are provided for the assembly of the global matrices. The numerically computed modal frequencies are compared against the literature. Besides, a simple, nonlinear mass-spring network is used to excite the plate and an efficient sound radiation model is also presented with point sources and fractional delay filters.

Finally, the linear finite element model is extended to the nonlinear von Kármán plate model with time-stepping methods. In the end, possibilities of model refinement are shortly discussed.