The Digital Pulse Forming as a Tool for the Analysis and Synthesis of Wind Instrument Sounds

Abstract

A digital real-time-capable analysis- and synthesis-system for wind instrument sounds, based on the pulse forming theory, has been developed. The performance of the system was exemplarily demonstrated afterwards in a perceptual pilot experiment. In order to validate the pulse forming theory as a model for the sound generating process of wind instruments, it was necessary to compare the pulse forming principle with other popular theories explaining the sound production of wind instruments. Based on theoretical considerations as well as practical investigations, it was shown that the pulse forming theory provides a better explanation for the genesis of instrument-typical constant timbre of wind instruments than other theories (i.e., source-filter or interference-theory).

In order to obtain a robust theoretical fundament for the analysis- and synthesis-framework, it was first necessary to prove the digital pulse forming to be a particularly suitable method for wind instrument synthesis. Thus, other appropriate techniques as well as the digital pulse forming itself were examined. Both the waveguide synthesis and the digital pulse forming proved to be adequate for synthesizing wind instrument sounds according to the natural sound production process. The advantage of the digital pulse forming, however, is the specific level of abstraction which leads to a more efficient and descriptive synthesis algorithm. This is of great value concerning the implementation in an analysis-framework, because parameter changes at different model layers are much easier to handle.

The concept and construction of the analysis- and synthesis-framework was based on the Variophon, an analogue wind instrument synthesizer using pulse forming as the synthesis method. Various acoustic analyses were carried out during the development of the Variophon that significantly helped in transformation of the pulse forming principle onto a digital platform. Another aspect of the reconstruction was the conservation and reconditioning of some historically invaluable sound synthesis algorithms of the Variophon. By means of the developed environment it was possible to validate the pulse forming theory as a feasible explanation for the sound generating process of wind instruments as well as to simulate several novel experiments in the field of instrument acoustics. Further extensions of the framework and different application areas are discussed.

The relevance of micromodulations and vibrato in oboe sounds was examined in a prototypical perceptual experiment. One the one hand, this example demonstrated the performance of the developed analysis- and synthesis-framework; one the other hand, it could be shown that timbre modulation, in other words, realistic in-phase pulse width und cycle duration modulation, is an important factor for the perceived naturalness of oboe sounds. Even vibrato generation, which in many synthesis methods is achieved by means of simple AM- and/or FM-modulation, can be improved easily by using a pulse forming based timbre modulation.