

Editorial

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Model-based sound synthesis has become one of the most active research topics in musical signal processing and in musical acoustics. The earliest attempts in generating musical sound with a physical model were made over three decades ago. The first commercial products were seen only some twenty years later. Recently, many refinements to previous signal processing algorithms and several new ones have been introduced. We have learned that new signal processing methods can still be devised or old ones modified to advance the field.

Today there exist efficient model-based synthesis algorithms for many sound sources, while there are still some for which we do not have a good model. Certain issues, such as parameter estimation and real-time control, require further work for many model-based approaches. Finally, the capabilities of human listeners to perceive details in synthetic sound should be accounted for in a way similar as in perceptual audio coding in order to optimize the algorithms. The success and future of the model-based approach depends on researchers and the results of their work.

The roots of this special issue are in a European project

called ALMA (Algorithms for the Modelling of Acoustic Interactions, IST-2001-33059, see <http://www-dsp.elet.polimi.it/alma/>) where the guest editors and their research teams collaborated in the period from 2001 to 2004. The goal of the ALMA project was to develop an elegant, general, and unifying strategy for a blockwise design of physical models for sound synthesis. A “divide-and-conquer” approach was taken, in which the elements of the structure are individually modeled and discretized, while their interaction topology is separately designed and implemented in a dynamical and physically sound fashion. As a result, several high-quality demonstrations of virtual musical instruments played in a virtual environment were developed. During the ALMA project, the guest editors realized that this special issue could be created, since the field was very active but there had not been a special issue devoted to it for a long time.

This EURASIP JASP special issue presents ten examples of recent research in model-based sound synthesis. The first two papers are related to keyboard instruments. First Giordano and Jiang discuss physical modeling synthesis of the piano using the finite-difference approach. Then Välimäki et al.

show how to synthesize the sound of the harpsichord based on measurements of a real instrument. An efficient implementation using a visual software synthesis package is given for real-time synthesis.

In the third paper, Trautmann and Rabenstein present a multirate implementation of a vibrating string model that is based on the functional transformation method. In the next paper, Testa et al. investigate the modeling of stiff string behavior. The dispersive wave phenomenon, perceivable as inharmonicity in many string instrument sounds, is studied by deriving different physically inspired models.

In the fourth paper, Karjalainen and Erkut propose a very interesting and general solution to the problem of how to build composite models from digital waveguides and finite-difference time-domain blocks. The next contribution is from Guillemain, who proposes a real-time synthesis model of double-reed wind instruments based on a nonlinear physical model.

The paper by Howard and Rimell provides a viewpoint quite different from the others in this special issue. It deals with the design and implementation of user interfaces for model-based synthesis. An important aspect is the incorporation of tactile feedback into the interface.

Arroabarren and Carlosena have studied the modeling and analysis of human voice production, particularly the vibrato used in the singing voice. Source-filter modeling and sinusoidal modeling are compared to gain a deeper insight in these phenomena. Bensa et al. bring the discussion back to the physical modeling of musical instruments, with particular reference to the piano. They propose a source/resonator model of hammer-string interaction aimed at a realistic production of piano sound. Finally, Glass and Fukuodome incorporate a plucked-string model into an audio coder for audio compression and instrument synthesis.

The guest editors would like to thank all the authors for their contributions. We would also like to express our deep gratitude to the reviewers for their diligent efforts in evaluating all submitted manuscripts. We hope that this special issue will stimulate further research work on model-based sound synthesis.

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Vesa Välimäki was born in Kuorevesi, Finland, in 1968. He received the M.S. degree, the Licentiate of Science degree, and the Doctor of Science degree, all in electrical engineering from Helsinki University of Technology (HUT), Espoo, Finland, in 1992, 1994, and 1995, respectively. He was with the HUT Laboratory of Acoustics and Audio Signal Processing from 1990 to 2001. In 1996, he



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Augusto Sarti, born in 1963, received the "Laurea" degree (1988, cum laude) and the Ph.D. (1993) in electrical engineering, from the University of Padua, Italy, with research on nonlinear communication systems. He completed his graduate studies at the University of California at Berkeley, where he spent two years doing research on nonlinear system control and on motion planning of nonholonomic systems. In 1993 he joined the Dipartimento di Elettronica e Informazione of the Politecnico di Milano, where he is now an Associate Professor. His current research interests are in the area of digital signal processing, with particular focus on sound analysis, processing and synthesis, image processing, video coding and computer vision. Augusto Sarti authored over 100 scientific publications. He is leading the Image and Sound Processing Group (ISPG) at the Dipartimento di Elettronica e Informazione of the Politecnico di Milano, which contributed to numerous national projects and eight European research projects. He is currently coordinating the IST-2001-33059 European Project "ALMA: Algorithms for the Modelling of Acoustic Interactions," and is co-coordinating the IST-2000-28436 European Project "ORIGAMI: A new paradigm for high-quality mixing of real and virtual."



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Rudolf Rabenstein received the “Diplom-Ingenieur” and “Doktor-Ingenieur” degrees in electrical engineering and the “Habilitation” degree in signal processing, all from the University of Erlangen-Nuremberg, Germany in 1981, 1991, and 1996, respectively. He worked with the Telecommunications Laboratory, University of Erlangen-Nuremberg, from 1981 to 1987. From 1998 to 1991, he was with the Physics Department of the University of Siegen, Germany. In 1991, he returned to the Telecommunications Laboratory of the University of Erlangen-Nuremberg. His research interests are in the fields of multidimensional systems theory, multimedia signal processing, and computer music. Rudolf Rabenstein is the author and coauthor of more than 100 scientific publications, has contributed to various books and book chapters, and holds several patents in audio engineering. He is a Board Member of the School of Engineering of the Virtual University of Bavaria, Germany and a member of several engineering societies.



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