

# Stanford

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## Julius Smith

Professor of Music, and by courtesy, of Electrical Engineering

### Bio

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#### BIO

Smith is a professor of music and (by courtesy) electrical engineering (Information Systems Lab) based at the Center for Computer Research in Music and Acoustics (CCRMA). Teaching and research pertain to music and audio applications of signal processing. Former software engineer at NeXT Computer, Inc., responsible for signal processing software pertaining to music and audio. For more, see <https://ccrma.stanford.edu/~jos/>.

#### ACADEMIC APPOINTMENTS

- Professor, Music
- Professor (By courtesy), Electrical Engineering

#### HONORS AND AWARDS

- Keynote Speaker, Digital Audio Effects (DAFx) Conference, Edinburgh (2017)
- Keynote Speaker, Linux Audio Conference (LAC-2015), Mainz, Germany (2015)
- Plenary Speaker, IEEE International Workshop on Recent Trends in Signal Processing, Cluj-Napoca, Romania (2015)
- CIRMMT Distinguished Lecture, McGill University (2010)
- Keynote Speaker, Digital Audio Effects (DAFx) Conference, Como Italy (2009)
- Fellow, Audio Engineering Society (2008)
- Heyser Lecture, Audio Engineering Society Conference (San Francisco) (2006)
- Invited Masterclass, Audio Engineering Society Conference (San Francisco) (2006)
- Keynote Speaker, Digital Audio Effects Conference (DAFx) (2006)
- Keynote Speaker, IEEE Workshop on Applications of Signal Processing to Audio & Acoustics (WASPAA) (2005)
- Fellow, Acoustical Society of America (2003)
- Invited Speaker, first in the Opening Session, Stockholm Musical Acoustics Conference (2003)
- Technical Program Chair, IEEE Audio & Acoustics Signal Processing Workshop (1997)
- Member, IRCAM Scientific Council (1996)
- Plenary Speaker, Nordic Acoustics Conference (1996)
- Keynote Speaker, Tempo Reale Workshop on Physical Modeling (1996)
- Inventor Recognition Award, Stanford Office of Technology and Licensing (1996)
- Keynote Speaker, ICMC-91 (Int. Computer Music Conf.) (1996)
- Graduate Fellowship, Hertz (Fall 1977 to Fall 1982)

## PROFESSIONAL EDUCATION

- B.Sc. (Hons), Rice University , Electrical Engineering (1975)
- PhD, Stanford University , Electrical Engineering (1983)

## LINKS

- JOS Home Page: <https://ccrma.stanford.edu/~jos/>

## Teaching

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### COURSES

#### 2021-22

- Audio DSP Projects in Faust and C++: MUSIC 320C (Spr)
- Graduate Research in Music Technology: MUSIC 423 (Spr)

#### 2020-21

- Research Seminar in Computer-Generated Music: MUSIC 220C (Spr)
- Software Projects in Music/Audio Signal Processing: MUSIC 320C (Spr)

#### 2019-20

- Signal Processing Models in Musical Acoustics: MUSIC 420A (Win)
- Time-Frequency Audio Signal Processing: MUSIC 421A (Spr)

#### 2018-19

- Signal Processing Models in Musical Acoustics: MUSIC 420A (Win)
- Time-Frequency Audio Signal Processing: MUSIC 421A (Spr)

### STANFORD ADVISEES

#### Doctoral Dissertation Advisor (AC)

Mark Rau, Travis Skare

#### Master's Program Advisor

Angela Lee, Dirk Roosenburg

#### Doctoral (Program)

Mark Rau, Travis Skare

## Publications

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### PUBLICATIONS

- **A landmark article on nonlinear time-domain modeling in musical acoustics.** *The Journal of the Acoustical Society of America*  
Scavone, G., Smith, J. O.  
2021; 150 (2): R3
- **A landmark article on nonlinear time-domain modeling in musical acoustics** *JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA*  
Scavone, G., Smith, J. O.  
2021; 150 (2): R3-R4
- **Electric-to-acoustic pickup processing for string instruments: An experimental study of the guitar with a hexaphonic pickup.** *The Journal of the Acoustical Society of America*  
Rau, M., Abel, J. S., James, D., Smith, J. O.

2021; 150 (1): 385

- **Electric-to-acoustic pickup processing for string instruments: An experimental study of the guitar with a hexaphonic pickup** *JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA*  
Rau, M., Abel, J. S., James, D., Smith, J. O.  
2021; 150 (1): 385-397
- **State-space modeling of sound source directivity: An experimental study of the violin and the clarinet.** *The Journal of the Acoustical Society of America*  
Maestre, E., Scavone, G. P., Smith, J. O.  
2021; 149 (4): 2768
- **Improved Real-Time Monophonic Pitch Tracking with the Extended Complex Kalman Filter** *JOURNAL OF THE AUDIO ENGINEERING SOCIETY*  
Das, O., Smith, J. O., Chafe, C.  
2020; 68 (1-2): 78–86
- **Converting Series Biquad Filters Into Delayed Parallel Form: Application to Graphic Equalizers** *IEEE TRANSACTIONS ON SIGNAL PROCESSING*  
Liski, J., Bank, B., Smith, J. O., Valimaki, V.  
2019; 67 (14): 3785–95
- **Generalized Wave Digital Filter Realizations of Arbitrary Reciprocal Connection Networks** *IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I-REGULAR PAPERS*  
Bernardim, A., Werner, K., Smith, J., Sarti, A.  
2019; 66 (2): 694–707
- **Modeling Circuits With Arbitrary Topologies and Active Linear Multiports Using Wave Digital Filters** *IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I-REGULAR PAPERS*  
Werner, K., Bernardini, A., Smith, J. O., Sarti, A.  
2018; 65 (12): 4233–46
- **Modeling sound scattering using a combination of the edge source integral equation and the boundary element method.** *The Journal of the Acoustical Society of America*  
Martin, S. R., Svensson, U. P., Slechta, J., Smith, J. O.  
2018; 144 (1): 131
- **Modeling sound scattering using a combination of the edge source integral equation and the boundary element method** *JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA*  
Martin, S. R., Svensson, U., Slechta, J., Smith, J. O.  
2018; 144 (1): 131-141
- **Mobile Music, Sensors, Physical Modeling, and Digital Fabrication: Articulating the Augmented Mobile Instrument** *APPLIED SCIENCES-BASEL*  
Michon, R., Smith, J., Wright, M., Chafe, C., Granzow, J., Wang, G.  
2017; 7 (12)
- **Perceptual Spatial Audio Recording, Simulation, and Rendering** *IEEE SIGNAL PROCESSING MAGAZINE*  
Hacihabiboglu, H., De Sena, E., Cvetkovic, Z., Johnston, J., Smith, J. O.  
2017; 34 (3): 36-54
- **Joint Modeling of Bridge Admittance and Body Radiativity for Efficient Synthesis of String Instrument Sound by Digital Waveguides** *IEEE-ACM TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Maestre, E., Scavone, G. P., Smith, J. O.  
2017; 25 (5): 1128-1139
- **Design of Recursive Digital Filters in Parallel Form by Linearly Constrained Pole Optimization** *IEEE SIGNAL PROCESSING LETTERS*  
Maestre, E., Scavone, G. P., Smith, J. O.  
2016; 23 (11): 1547-1550
- **Modeling Nonlinear Wave Digital Elements Using the Lambert Function** *IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I-REGULAR PAPERS*  
Bernardini, A., Werner, K. J., Sarti, A., Smith, J. O.  
2016; 63 (8): 1231-1242
- **More Than Fifty Years of Artificial Reverberation**

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Valimaki, V., Parker, J. D., Savioja, L., Smith, J. O., Abel, J. S., Goetze, S., Spriet, A.  
AUDIO ENGINEERING SOC INC.2016

- **Wave Digital Filter Modeling of Circuits with Operational Amplifiers**  
Werner, K., Dunkel, W., Rest, M., Olsen, M., Smith, J. O., IEEE  
IEEE.2016: 1033-1037
- **RESOLVING GROUPED NONLINEARITIES IN WAVE DIGITAL FILTERS USING ITERATIVE TECHNIQUES**  
Olsen, M., Werner, K., Smith, J. O., Rajmic, P., Rund, F., Schimmel, J.  
BRNO UNIV TECHNOLOGY, FAC ELECTRICAL ENG & COMMUNICATION.2016: 279-286
- **THE FENDER BASSMAN 5F6-A FAMILY OF PREAMPLIFIER CIRCUITS-A WAVE DIGITAL FILTER CASE STUDY**  
Dunkel, W., Rest, M., Werner, K., Olsen, M., Smith, J. O., Rajmic, P., Rund, F., Schimmel, J.  
BRNO UNIV TECHNOLOGY, FAC ELECTRICAL ENG & COMMUNICATION.2016: 263-270
- **RT-WDF-A MODULAR WAVE DIGITAL FILTER LIBRARY WITH SUPPORT FOR ARBITRARY TOPOLOGIES AND MULTIPLE NONLINEARITIES**  
Rest, M., Dunkel, W., Werner, K., Smith, J. O., Rajmic, P., Rund, F., Schimmel, J.  
BRNO UNIV TECHNOLOGY, FAC ELECTRICAL ENG & COMMUNICATION.2016: 287-294
- **SYNTHESIS OF SOUND TEXTURES WITH TONAL COMPONENTS USING SUMMARY STATISTICS AND ALL-POLE RESIDUAL MODELING**  
Kim, H., Smith, J., Rajmic, P., Rund, F., Schimmel, J.  
BRNO UNIV TECHNOLOGY, FAC ELECTRICAL ENG & COMMUNICATION.2016: 129-136
- **Efficient Synthesis of Room Acoustics via Scattering Delay Networks** *IEEE-ACM TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
De Sena, E., Hacıhabiboglu, H., Cvetkovic, Z., Smith, J. O.  
2015; 23 (9): 1478-1492
- **WAVE DIGITAL FILTER ADAPTORS FOR ARBITRARY TOPOLOGIES AND MULTIPORT LINEAR ELEMENTS**  
Werner, K., Smith, J. O., Abel, J. S., Svensson, P., Kristiansen, U.  
NORWEGIAN UNIV SCI TECHNOL.2015: 379-86
- **DIGITAL MODELING OF STRING INSTRUMENT BRIDGE REFLECTANCE AND BODY RADIATIVITY FOR SOUND SYNTHESIS BY DIGITAL WAVEGUIDES**  
Maestre, E., Scavone, G. P., Smith, J. O., IEEE  
IEEE.2015
- **An Energetic Interpretation of Nonlinear Wave Digital Filter Lookup Table Error**  
Werner, K., Smith, J. O., IEEE  
IEEE.2015
- **HARMONIZING EFFECT USING SHORT-TIME TIME-REVERSAL**  
Kim, H., Smith, J. O., Svensson, P., Kristiansen, U.  
NORWEGIAN UNIV SCI TECHNOL.2015: 81-86
- **Multi-Port NonLinearities in Wave Digital Structures**  
Bernardini, A., Werner, K. J., Sarti, A., Smith, J. O., IEEE  
IEEE.2015
- **A GENERAL AND EXPLICIT FORMULATION FOR WAVE DIGITAL FILTERS WITH MULTIPLE/MULTIPORT NONLINEARITIES AND COMPLICATED TOPOLOGIES**  
Werner, K., Nangia, V., Smith, J. O., Abel, J. S., IEEE  
IEEE.2015
- **RESOLVING WAVE DIGITAL FILTERS WITH MULTIPLE/MULTIPORT NONLINEARITIES**  
Werner, K., Nangia, V., Smith, J. O., Abel, J. S., Svensson, P., Kristiansen, U.  
NORWEGIAN UNIV SCI TECHNOL.2015: 387-94
- **A PHYSICALLY-INFORMED, CIRCUIT-BENDABLE, DIGITAL MODEL OF THE ROLAND TR-808 BASS DRUM CIRCUIT**  
Werner, K., Abel, J. S., Smith, J. O., Int Audio Labs Erlangen  
INT AUDIO LABORATORIES ERLANGEN.2014: 159-66

- **SHORT-TIME TIME-REVERSAL ON AUDIO SIGNALS**  
Kim, H., Smith, J. O., Int Audio Labs Erlangen  
INT AUDIO LABORATORIES ERLANGEN.2014: 29-33
- **Towards a physical model of the berimbau: Obtaining the modal synthesis of the cabaza.** *journal of the Acoustical Society of America*  
Castellanos Macin, P., Smith, J. O.  
2013; 134 (5): 4243-?
- **Force-Sensitive Detents Improve User Performance for Linear Selection Tasks** *IEEE TRANSACTIONS ON HAPTICS*  
Berdahl, E., Smith, J. O., Weinzierl, S., Niemeyer, G.  
2013; 6 (2): 206-216
- **Fifty Years of Artificial Reverberation** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Valimaki, V., Parker, J. D., Savioja, L., Smith, J. O., Abel, J. S.  
2012; 20 (5): 1421-1448
- **Optimized Polynomial Spline Basis Function Design for Quasi-Bandlimited Classical Waveform Synthesis** *IEEE SIGNAL PROCESSING LETTERS*  
Pekonen, J., Juhan Nam, J., Smith, J. O., Valimaki, V.  
2012; 19 (3): 159-162
- **EXPLOITING THE HARMONIC STRUCTURE FOR SPEECH ENHANCEMENT** *IEEE International Conference on Acoustics, Speech and Signal Processing*  
Cho, E., Smith, J. O., Widrow, B.  
IEEE.2012: 4569-4572
- **Feedback control of acoustic musical instruments: Collocated control using physical analogs** *JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA*  
Berdahl, E., Smith, J. O., Niemeyer, G.  
2012; 131 (1): 963-973
- **Audio Signal Processing Using Graphics Processing Units** *JOURNAL OF THE AUDIO ENGINEERING SOCIETY*  
Savioja, L., Valimaki, V., Smith, J. O.  
2011; 59 (1-2): 3-19
- **Analysis and Synthesis of Coupled Vibrating Strings Using a Hybrid Modal-Waveguide Synthesis Model** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Lee, N., Smith, J. O., Valimaki, V.  
2010; 18 (4): 833-842
- **Introduction to the Special Issue on Virtual Analog Audio Effects and Musical Instruments** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Valimaki, V., Fontana, F., Smith, J. O., Zoelzer, U.  
2010; 18 (4): 713-714
- **Automated Physical Modeling of Nonlinear Audio Circuits For Real-Time Audio Effects-Part I: Theoretical Development** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Yeh, D. T., Abel, J. S., Smith, J. O.  
2010; 18 (4): 728-737
- **Alias-Suppressed Oscillators Based on Differentiated Polynomial Waveforms** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Valimaki, V., Nam, J., Smith, J. O., Abel, J. S.  
2010; 18 (4): 786-798
- **Efficient Antialiasing Oscillator Algorithms Using Low-Order Fractional Delay Filters** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Nam, J., Valimaki, V., Abel, J. S., Smith, J. O.  
2010; 18 (4): 773-785
- **Robust, Efficient Design of Allpass Filters for Dispersive String Sound Synthesis** *IEEE SIGNAL PROCESSING LETTERS*  
Abel, J. S., Valimaki, V., Smith, J. O.  
2010; 17 (4): 406-9

- **Virtual String Synthesis** *SCIENCE OF STRING INSTRUMENTS*  
Lee, N., Smith, J. O., Rossing, T. D.  
2010; 417-455
- **Spectral Delay Filters** *JOURNAL OF THE AUDIO ENGINEERING SOCIETY*  
Valimaki, V., Abel, J. S., Smith, J. O.  
2009; 57 (7-8): 521-531
- **Numerical methods for simulation of guitar distortion circuits** *COMPUTER MUSIC JOURNAL*  
Yeh, D. T., Abei, J. S., Vladimirescu, A., Smith, J. O.  
2008; 32 (2): 23-42
- **Audio Watermarking through Deterministic plus Stochastic Signal Decomposition** *EURASIP JOURNAL ON INFORMATION SECURITY*  
Liu, Y., Smith, J. O.  
2007
- **Parameterized finite difference schemes for plates: Stability, the reduction of directional dispersion and frequency warping** *IEEE TRANSACTIONS ON AUDIO SPEECH AND LANGUAGE PROCESSING*  
Bilbao, S., Savioja, L., Smith, J. O.  
2007; 15 (4): 1488-1495
- **Generative model of voice in noise for structured coding applications** *32nd IEEE International Conference on Acoustics, Speech and Signal Processing*  
Jinachitra, P., Smith, J. O.  
IEEE.2007: 281-284
- **Humming Control Interface for Hand-held Devices** *9th International ACM SIGACCESS Conference on Computers and Accessibility*  
Won, S. Y., Lee, D., Smith, J.  
ASSOC COMPUTING MACHINERY.2007: 259-260
- **Efficient time-varying loudness estimation via the hopping Goertzel DFT** *50th Midwest Symposium on Circuits and Systems*  
Cassidy, R. J., Smith, J. O.  
IEEE.2007: 362-363
- **Inducing unusual dynamics in acoustic musical instruments** *IEEE Conference on Control Applications*  
Berdahl, E., Smith, J. O.  
IEEE.2007: 411-416
- **Singer-dependent falsetto detection for live vocal processing based on support vector classification** *40th Asilomar Conference on Signals, Systems and Computers*  
Mysore, G. J., Cassidy, R. J., Smith, J. O.  
IEEE.2006: 1139-1142
- **Energy-conserving finite difference schemes for nonlinear strings** *ACTA ACUSTICA UNITED WITH ACUSTICA*  
Bilbao, S., Smith, J. O.  
2005; 91 (2): 299-311
- **Joint estimation of glottal source and vocal tract for vocal synthesis using Kalman smoothing and EM algorithm** *Workshop on Applications of Sigbak Processing to Audio and Acoustics*  
Jinachitra, P., Smith, J. O.  
IEEE.2005: 327-330
- **The simulation of piano string vibration: From physical models to finite difference schemes and digital waveguides** *JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA*  
Bensa, J., Bilbao, S., Kronland-Martinet, R., Smith, J. O.  
2003; 114 (2): 1095-1107
- **Finite difference schemes and digital waveguide networks for the wave equation: Stability, passivity, and numerical dispersion** *IEEE TRANSACTIONS ON SPEECH AND AUDIO PROCESSING*  
Bilbao, S., Smith, J. O.  
2003; 11 (3): 255-266

- **PHYSICAL MODELING USING DIGITAL WAVE-GUIDES** *COMPUTER MUSIC JOURNAL*  
Smith, J. O.  
1992; 16 (4): 74-98
- **SMITH,J.O. COMMENTS ON SULLIVAN KARPLUS-STRONG ARTICLE** *COMPUTER MUSIC JOURNAL*  
Smith, J. O.  
1991; 15 (2): 10-11
- **FUNDAMENTALS OF DIGITAL-FILTER THEORY** *COMPUTER MUSIC JOURNAL*  
Smith, J. O.  
1985; 9 (3): 13-23
- **EXTENSIONS OF THE KARPLUS-STRONG PLUCKED-STRING ALGORITHM** *COMPUTER MUSIC JOURNAL*  
Jaffe, D. A., Smith, J. O.  
1983; 7 (2): 56-69
- **A CONSTANT-GAIN DIGITAL RESONATOR TUNED BY A SINGLE COEFFICIENT** *COMPUTER MUSIC JOURNAL*  
Smith, J. O., ANGELL, J. B.  
1982; 6 (4): 36-40