

Nikunj Raghuvanshi

Researcher

Microsoft Research, 1 Microsoft Way, Redmond, USA

+1(604) 6937347 | nikunjr@microsoft.com | www.nikunjr.com

Research interests

I work at the intersection of computational acoustics and graphics, researching fast sound simulation techniques for games and Augmented/Virtual Reality. This includes wave modeling techniques for sound synthesis and propagation for increasing the realism of interactive spatial audio. My broader interest is to improve the believability of virtual worlds. I like to balance research contributions with practical impact: my work has been published at premiere venues while shipping in multiple major Microsoft products.

Highlight: Project Triton

Complex 3D scenes in computer games and AR/VR must look *and* sound believable to be immersive. Practical techniques for modeling light propagation are well-established but game audio engines remain far behind, relying on manually faking acoustic effects. Acoustical physics is extremely compute hungry. I conceived and have led Triton for a decade. It is a system that precomputes wave physics to automatically model effects like smooth occlusion and reverberation directly from 3D scene geometry and materials. Today it is a proven solution, having shipped in Windows 10 mixed reality portal and AAA Microsoft games: Gears of War 4 and Sea of Thieves, being experienced by millions of users worldwide.

Education

Ph.D. in Computer Science, 2009

School: UNC Chapel Hill

Advisor: Prof. Ming C. Lin

Thesis: "Interactive Physically-based Sound Simulation"

Bachelor of Technology in Computer Science, 2003

School: Indian Institute of Technology (IIT) Kanpur, India

Mentor: Prof. Sanjay G. Dhande, Director, IIT Kanpur

Employment

Researcher, Microsoft Research, Dec 2009 – Present

- Project Triton: wave propagation for games and AR/VR (see above)
- Fast rigid body sound synthesis
- Interactive virtual musical instrument modeling on graphics processors
- Real-time articulatory speech synthesis on graphics processors

Research Assistant, UNC Chapel Hill, Aug 2005 – May 2008 & May 2009 – Dec 2009

Advisor: Prof. Ming C. Lin

- Developed fast rigid body impact and rolling sound synthesis techniques exploiting auditory perception to obtain orders of magnitude speedups.
- Invented the Adaptive Rectangular Decomposition (ARD) solver that employs analytical solutions to the wave equation to result in 10-100x speed compared to standard finite difference techniques.
- **Entire PhD codebase licensed by Microsoft**

Research Intern, Microsoft Research, May 2008 – May 2009

Mentors: Dr. John Snyder, Principal Researcher & Dr. Naga K. Govindaraju, Senior Scientist
 Worked on accelerating my ARD solver on graphics processors. Using ARD to precompute wave propagation, built the world's first real-time wave-based sound propagation system that could accurately model wave effects like diffraction. Published in SIGGRAPH 2010.

Research Assistant, UNC Chapel Hill, Aug 2004 – Aug 2005

Advisor: Prof. Dinesh Manocha
 Worked on high performance sorting using graphics processors (GPU). I implemented various database operations to showcase benefits, such as streaming frequencies and quantiles.

Project Associate, IIT Kanpur, Aug 2003 – May 2004

Advisor: Prof. Sanjay G. Dhande, Director
 Ray-casting for fast silhouette extraction from NURBS surfaces.

Research Intern, INRIA Sophia-Antipolis, April – June 2002

Mentor: Dr. Herve Delingette, Research Director
 Worked on fast volume rendering using hardware-accelerated OpenGL for medical image visualization.

Technology Transfers

Sea of Thieves, RARE Studios, Mar 2018

Collaborators: Jon Vincent
 Triton is used to model smooth wave occlusion effects such as gunfire outside heard inside a ship. I helped in code integration, debugging, and provided consultation on a novel modular acoustics design to meet the game's needs.

Windows 10 Mixed Reality Portal, Nov 2017

Collaborators: Keith Godin, Ryan Rohrer, Noel Cross
 Triton processes a wide variety of application sounds in the virtual "CliffHouse" environment, providing occlusion and reverberation in the virtual space to immerse the user. I helped tune the acoustic quality, consulted on integration, addressed bugs, and took feedback on missing spatial audio effects to guide future research.

Gears of War 4, The Coalition Studio, Oct 2016

Collaborators: John Morgan, John Tennant, Jimmy Smith
 Triton was incubated from a research project to a production-quality acoustics solution during this 4-year collaboration. Improvements were made to the material modeling, spatial sampling,

memory/CPU demands, disk usage, and precomputation speed. I held primary responsibility for the research improvements alongside development and maintenance of the core C++ tools and library.

Crackdown 2, Microsoft Studios, July **2010**

Collaborators: Kristofor Mellroth, Guy Whitmore

Project was led by Brandon Lloyd. We developed a technique to use a single input clip to generate a variety of random, plausible variations for impact sounds to avoid repetition in an open-world game.

Game Credits

Sea of Thieves, special thanks

Gears of War 4, engine development

Peer-reviewed publications

Note: SIGGRAPH is the top venue in computer graphics and interactive techniques, with acceptance rate of ~20%. Accepted papers are published in a special issue of the top journal in the field, ACM Trans. on Graphics.

Parametric Directional Coding for Precomputed Sound Propagation

Nikunj Raghuvanshi, John Snyder

ACM Transactions on Graphics (SIGGRAPH), August **2018** (to appear)

Wave Acoustics in a Mixed Reality Shell

Keith W. Godin, Ryan Rohrer, John Snyder, **Nikunj Raghuvanshi**

AES International Conference on Audio for Virtual and Augmented Reality, August **2018** (to appear)

Towards real-time two-dimensional wave propagation for articulatory speech synthesis

Victor Zappi, Arvind Vasuvedan, Andrew Allen, **Nikunj Raghuvanshi**, Sidney Fels

Proceedings of Meetings on Acoustics, **2016**

Aerophones in Flatland: Interactive Wave Simulation of Wind Instruments

Andrew Allen, **Nikunj Raghuvanshi**

ACM Transactions on Graphics (SIGGRAPH), August **2015**

Parametric Wave Field Coding for Precomputed Sound Propagation

Nikunj Raghuvanshi, John Snyder

ACM Transactions on Graphics (SIGGRAPH), August **2014**

RoomAlive: Magical Experiences Enabled by Scalable, Adaptive Projector-Camera Units

Brett Jones, Rajinder Sodhi, Michael Murdock, Ravish Mehra, Hrvoje Benko, Andrew Wilson, Eyal Ofek, Blair MacIntyre, **Nikunj Raghuvanshi**, Lior Shapira

ACM Symposium on User Interface Software and Technology (UIST), **2014**

Acoustic pulse propagation in an urban environment using a three-dimensional numerical simulation

Ravish Mehra, **Nikunj Raghuvanshi**, A. Chandak, Donald G. Albert, D. Keith Wilson, Dinesh Manocha

The Journal of the Acoustical Society of America, **2014**

Wave-Based Sound Propagation in Large Open Scenes using an Equivalent Source Formulation
Ravish Mehra, **Nikunj Raghuvanshi**, Lakulish Antani, Anish Chandak, Sean Curtis, Dinesh Manocha
ACM Transactions on Graphics, **2013**

An Efficient GPU-based Time Domain Solver for the Acoustic Wave Equation
Ravish Mehra, **Nikunj Raghuvanshi**, Lauri Savioja, Ming Lin, Dinesh Manocha
Journal of Applied acoustics (Elsevier), **2012**

Sound synthesis for Impact Sounds in Video Games
D. Brandon Lloyd, **Nikunj Raghuvanshi**, and Naga K. Govindaraju
ACM Symposium on Interactive 3D Graphics and Games (I3D), **2011**

Precomputed Wave Simulation for Real-Time Sound Propagation of Dynamic Sources in Complex Scenes
Nikunj Raghuvanshi, John Synder, Ravish Mehra, Ming C. Lin, and Naga K. Govindaraju
ACM Transactions on Graphics (SIGGRAPH), **2010**

Efficient Numerical Acoustic Simulation on Graphics Processors using Adaptive Rectangular Decomposition
Nikunj Raghuvanshi, Brandon Lloyd, Naga K. Govindaraju, and Ming C. Lin
European Acoustics Association Symposium on Auralization, **2009**

Efficient and Accurate Sound Propagation using Adaptive Rectangular Decomposition
Nikunj Raghuvanshi, Rahul Narain and Ming C. Lin
IEEE Transactions on Visualization and Computer Graphics, **2009**

Accelerated Wave-based Acoustic Simulation
Nikunj Raghuvanshi, Nico Galoppo and Ming C. Lin
ACM Solid and Physical Modeling Symposium, **2008**

Real-Time Sound Synthesis and Propagation for Games
Nikunj Raghuvanshi, Christian Lauterbach, Anish Chandak, Dinesh Manocha, and Ming C. Lin
Communications of the ACM, **2007**

Physically Based Sound Synthesis for Large-Scale Virtual Environments
Nikunj Raghuvanshi and Ming C. Lin
IEEE Computer Graphics and Applications, **2007**

Interactive Sound Synthesis for Large Scale Environments
Nikunj Raghuvanshi and Ming C. Lin
Proceedings of the ACM Symposium on Interactive 3D Graphics and Games (I3D), **2006**

Fast and Approximate Stream Mining of Quantiles and Frequencies Using Graphics Processors
Naga K. Govindaraju, **Nikunj Raghuvanshi**, and Dinesh Manocha
Proceedings of ACM SIGMOD, **2005**

Raytraced rendering using t-buffer and shadow-buffer

Nikunj Raghuvanshi and Sanjay G. Dhande

International Journal of Information Technology, **2004**

Tech reports

A Cache-Efficient Sorting Algorithm for Database and Data Mining Computations using Graphics Processors

Naga K. Govindaraju, **Nikunj Raghuvanshi**, Michael Henson, and Dinesh Manocha

Department of Computer Science, UNC Chapel Hill, Tech. Report, **2005**

Patents

Directional Propagation, MS404528-US-PSP, disclosure filed May 15, **2018**

Virtually Visualizing Energy, **2018**

Jaron Lanier, Kishore Rathinavel, Nikunj Raghuvanshi

US Patent #9,922,463

Enhanced spatial impression for home audio, **2017**

Nikunj Raghuvanshi, Daniel Morris, Andrew Wilson, Yong Rui, Desney Tan, Jeannette Wing

US Patent #9,560,445

Dynamic calibration of an audio system, **2017**

Desney Tan, Daniel Morris, Andrew Wilson, Yong Rui, Nikunj Raghuvanshi, Jeannette Wing

US Patent #9,729,984

Parametric Wave Field Coding for Real-Time Sound Propagation for Dynamic Sources, **2016**

Nikunj Raghuvanshi, John Snyder

US Patent #9,510,125

Real-Time Sound Propagation For Dynamic Sources, **2016**

Nikunj Raghuvanshi, John Snyder, Ming C. Lin, Naga Govindaraju

US Patent #9,432,790

Privacy Preserving Sensor Apparatus, MS#339904.02, filed on Jan 18, **2014**

Structural Element For Sound Field Estimation And Production, MS#339901.01, filed Jan 9, **2014**

Adapting Audio Based Upon Detected Environmental Acoustics, MS#339900.01, filed Dec 20, **2013**

Abstracts & Talks

Note: First-authored paper presentations are **not** included for brevity

[Invited] Triton: Practical pre-computed sound propagation for games and virtual reality, Nikunj Raghuvanshi, John Tennant, John Snyder, *The Journal of the Acoustical Society of America* 141 (5), **2017**

'Gears of War 4', Project Triton: Pre-Computed Environmental Wave Acoustics, jointly with John Tennant, *Game Developers Conference*, Mar **2016**. [[Slide deck](#) (600MB)]

[Invited] Numerical wave simulation for interactive audio-visual applications, Nikunj Raghuvanshi, Andrew Allen, John Snyder, *The Journal of the Acoustical Society of America* 139 (4), **2016**

[Invited] Adaptive rectangular decomposition: A spectral, domain-decomposition approach for fast wave solution on complex scenes, Nikunj Raghuvanshi, Ravish Mehra, Dinesh Manocha, Ming C. Lin, *The Journal of the Acoustical Society of America* 132 (3), **2012**

[Invited] Real-time wave acoustics for games, *Meeting of Audio Engineering Society (AES)*, Oct **2011**

Real-time auralization of wave simulation in complex three-dimensional acoustic spaces, *Meeting of the Acoustical Society of America*, May **2011**

Sound Synthesis in Crackdown2, *Microsoft Gamefest*, **2011**

[Rated among top talks at GDC 2011] Sound Synthesis in Crackdown2 and Wave Acoustics for Games, *Game Developers Conference (GDC)*, **2011**

Interactive Physically-based Sound Synthesis and Propagation, *Microsoft Research*, **2009**

Real-time Physically-based Sound Synthesis for Games, *Game Developers Conference (GDC)*, **2007**

Perceptual Optimizations for Interactive Sound Synthesis in Virtual Environments, *as part of course on "Exploiting Perception in High-Fidelity Virtual Environments, ACM SIGGRAPH*, **2006**

Professional Service

Program Committee Member Technical Papers, ACM SIGGRAPH **2016, 2017**

Program Committee Member Technical Papers, ACM Symposium on Computer Animation (SCA) **2016, 2017**

Reviewer [Graphics] ACM SIGGRAPH, SIGGRAPH Asia, ACM Symposium on Computer Animation (SCA), ACM Transactions on Graphics, Eurographics, Computer Graphics Forum

Reviewer [Acoustics] Journal of Acoustical Society of America, IEEE Transactions on Audio, Speech and Language Processing (TASL), ASME Journal of Vibration and Acoustics, Computer Music Journal

Reviewer [HCI/AR] Conference on Human Factors in Computing Systems (CHI), User Interface Software and Technology (UIST), IEEE International Symposium on Mixed and Augmented Reality

PhD Committee Service

Zhimin Ren, **2013**

Thesis: "Real-Time Physically Based Sound Synthesis and Application in Multimodal Interaction"

Advisor: Ming C. Lin, UNC Chapel Hill

Hengchin Yeh, **2013**

Thesis: "Adaptive Modeling of Details for Physically-based Sound Synthesis and Propagation"

Advisor: Dinesh Manocha, UNC Chapel Hill

Lakulish Antani, **2012**

Thesis: "Real-Time Sound Propagation using Precomputation and Statistical Approximations"

Advisor: Dinesh Manocha, UNC Chapel Hill

Intern Mentorship

Christoph Hold, TU Berlin, **2017**

Audio-visual 3D sound source localization

Hossein Mansour, McGill University, **2016**

Investigations into improving the quality of current interactive sound synthesis techniques

Chakravarty Reddy Alla Chaitanya, McGill University, **2015**

Adaptive sampling for interactive sound propagation (shipped as part of Triton)

Andrew Allen, UCSD, **2014**

Interactive 2D wind instrument simulation on graphics processors

Alok Meshram, UNC Chapel Hill, **2013**

Improving scene terminating perfectly-matched-layer absorbers for numerical acoustic simulations

Ravish Mehra, UNC Chapel Hill, **2012**

Extracting directional information accurately from wave simulations