

# Zhongqing Han

SOFTWARE ENGINEER · SIMULATION RESEARCH ENGINEER

The George M. Low Center for Industrial Innovation, 110 8th St, Troy, NY 12180

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## Education

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### Rensselaer Polytechnic Institute, Center for Modeling, Simulation, and Imaging in Medicine (CeMSIM)

Troy, NY

PH.D. IN MECHANICAL ENGINEERING, SUPERVISED BY PROF. SUVRANU DE. GPA 3.95/4.0

Expected, Jul. 2018

- THESIS: Real-time simulation of Electrosurgical procedures

### University of Science and Technology of China, Department of Precision Machinery and Precision Instrumentation

China

M.S. IN MECHANICAL ENGINEERING

Jun. 2012

### University of Science and Technology of China, Department of Precision Machinery and Precision Instrumentation

China

B.S. IN MECHANICAL ENGINEERING

Jun. 2009

## Professional Skills

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### Research

PHYSICAL SIMULATION, RIGID/SOFT BODY MODELING, SURGICAL SIMULATION/TRAINING, MACHINE LEARNING

### Operating Systems

WINDOWS, LINUX

### Programming

C++/C(PROFICIENT), MATLAB(PROFICIENT), PYTHON(PROFICIENT), CUDA(PRIOR EXPERIENCE), WebGL(PRIOR EXPERIENCE), QT(INTERMEDIATE), VTK(PROFICIENT), TENSORFLOW(INTERMEDIATE)

### Game Engines

UNITY(PRIOR EXPERIENCE), UNREAL(PRIOR EXPERIENCE), PHYSX/FLEX (PRIOR EXPERIENCE)

### VR and haptic device

ZSPACE, HTC VIVE, LEAP MOTION, TOUCH HAPTIC DEVICE

## Core Courses

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### Mathematics

COMPUTATIONAL LINEAR ALGEBRA, NONLINEAR PROGRAMMING

### Mechanics

MECHANICS OF SOLIDS, INTRODUCTION TO HAPTICS, FUNDAMENTALS OF FINITE ELEMENT, FINITE ELEMENT PROGRAMMING

### Computer Science

ALGORITHMS: DESIGN AND ANALYSIS, PARALLEL COMPUTING, ADVANCED COMPUTER GRAPHICS, MACHINE LEARNING, PHYSICS BASED ANIMATION

# Research Projects

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## Project Summary

Conducted research and development on a five year NIH-funded project "Virtual Electrosurgical Skill Trainer (VEST)". Built a virtual reality (VR) based trainer (5 modules) with visual and haptic feedback, allowing the trainees to attain competence in a controlled environment. Overcome several technological challenges including (a) Realistic physics-based modeling of the complex bio-physics; (b) Real-time interactive computing; (c) Novel realistic VR interfaces and haptic feedback

### Accelerating multi-physics simulation with convolutional networks<sup>(b)</sup>

Troy, NY

RESEARCH ASSISTANT AT CEMSIM

Feb. 2018 - present

- Investigating the possibility of using convolutional networks to reduce the computational complexity of large scale multiphysics simulation in electrosurgery
- Performing data-augmentation to the input pressure fields without the need of running exact solvers
- Creating a set of geometry using level set evolution with randomized velocity for generalization performance with topological change

### Characterization of mechanics of electrosurgical cutting for liver tissue<sup>(a)</sup>

Troy, NY

RESEARCH ASSISTANT AT CEMSIM

Dec. 2017 - present

- Performing ex vivo tissue experiments to determine fracture toughness of liver tissue using an Electrosurgical Robotic Arm system and infrared thermometry
- Developing an inverse optimization model to characterize the mechanics of electrosurgical cutting

### Multi-physics Model for Electrosurgical Cutting of Soft Tissue<sup>(a,b)</sup>

Troy, NY

RESEARCH ASSISTANT AT CEMSIM

Jul. 2016 - Oct. 2017

- Developed deflation based block preconditioner for solving large scale multi-physics problem that resulted in linear increase in computational cost with increase in number of degrees of freedom
- Proposed cellular level micromechanical model to describe thermo-mechanical response of soft tissue
- Developed computationally efficient and thermodynamically consistent level set method to tissue fracture

### Electromagnetic Simulations (Current Pathway) on AustinMan Voxel Model<sup>(a,b,c)</sup>

Troy, NY & Boston, MA & Carrboro, NC

RESEARCH ASSISTANT AT CEMSIM & ALLIED HEALTH PROFESSIONAL MEMBER AT CARL J. SHAPIRO SIMULATION &

Sep. 2015 - Jun. 2016

SKILLS CENTER & LONG-TERM VISITOR AT KITWARE

- Developed an immersive and interactive GUI (QT, VTK) in zspace, later transferred to HTC Vive with Leap Motion
- Demonstrated current flow through virtual human based on Maxwell's equations and how dispersive electrode protects the patient
- Designed several clinically relevant abnormal scenarios due to any abnormal associated conditions (excessive body hair, previous scarring, implants)
- Performed pilot study at Carl J. Shapiro Simulation & Skills Center and face validation at SAGES learning center, with consistently high Likert assessment scores.

### Development of the Virtual Electrosurgery Skill Trainer (VEST) for Monopolar Electrosurgical Tasks<sup>(b,c)</sup>

Troy, NY & Boston, MA

RESEARCH ASSISTANT AT CEMSIM

Jan. 2014 - Jun. 2015

- Developed the monopolar electrosurgery interactions that include cutting, coagulation and fulguration in VEST
- Controlled the power settings and modes of operation by a virtual electrosurgical unit
- Designed a hardware interface to connect laparoscopic surgical tools with touch haptic device using a trocar mechanism

### Physics-based Real Time Computational Technology for Electrosurgical Procedures<sup>(a,b,c)</sup>

Troy, NY

RESEARCH ASSISTANT AT CEMSIM

Jan. 2013 - Nov. 2013

- Presented a real-time and physically realistic simulation of electrosurgery, by modeling the electrical, thermal and mechanical properties as three iteratively solved finite element models
- Proposed a dynamic triangulation algorithm based on isotherms to provide sub-finite element graphical rendering of vaporized tissue
- Utilized block compressed row storage (BCRS) structure for computationally efficient changes in the tissue topology
- Transitioned the techniques to a virtual laparoscopic adjustable gastric banding (LAGB) surgical simulator

### Virtual Basic Laparoscopic Skill Trainer (VBLaST) - Peg Transfer<sup>(a,b,c)</sup>

Troy, NY

RESEARCH ASSISTANT AT CEMSIM

Sep. 2012 - Dec. 2012

- Developed robust ambidextrous manipulation in virtual environment with haptic feedback (similar to robotic grasping and manipulation simulation)
- Resolved rigid body dynamics, collision detection/response and positioning

# Experience

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## Professional Experience

- Visiting Allied Health for **SAGES** (Society of American Gastrointestinal and Endoscopic Surgeons) 2017 Annual Meeting, Houston, Texas, March 2017
- Faculty of Workshop - VEST at the 9th Annual **ACS-AEI** (Division of Education of the American College of Surgeons and the Program for Accreditation of Education Institutes) Postgraduate Course, Carl J. Shapiro Simulation & Skills Center, Beth Israel Deaconess Medical Center, Boston, Massachusetts, September 2016
- Visiting Allied Health for **SAGES** (Society of American Gastrointestinal and Endoscopic Surgeons) 2016 Annual Meeting, Boston, Massachusetts, March 2016
- Long-term visitor at **Kitware**, Developed interactive GUI using VTK in the virtual environment and contributed to the Interactive Medical Simulation Toolkit (IMSTK), which is a free & open source software toolkit written in C++ that aids rapid prototyping of interactive multi-modal surgical simulations, Carrboro North Carolina, May 2016 - Present
- **IDEAS** (Innovation, Design and Emerging Alliances in Surgery: Virtual Surgery) workshop, Carl J. Shapiro Simulation & Skills Center, Beth Israel Deaconess Medical Center, Boston, Massachusetts, November 2013

## Teaching Experience

- Teaching assistant for the undergraduate Vibrations class, Aug. 2014 - Dec. 2014
- Teaching assistant for the undergraduate Introduction to Manufacturing Planning class, Jan. 2013 - May 2013
- Teaching assistant for the undergraduate Introduction to Engineering Analysis class, Aug. 2012 - Dec. 2012

# Publications

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## Journals

- **Z. Han**, Rahul, and S. De, Accelerating multiphysics simulation for electrosurgery with convolutional networks, prepared for *Comput. Methods Appl. Mech. Engrg.*, 2018
- M. Dombek, C. A. López, **Z. Han**, D. B. Jones, J. Olasky, S. Schwaitzberg, C. Cao, S. De, FUSE certification enhances performance on a virtual computer based simulator for dispersive electrode placement, *Surgical Endoscopy*, 2018, pp 1-6
- **Z. Han**, Rahul, and S. De, A multiphysics model for radiofrequency activation of soft hydrated tissues, accepted by *Comput. Methods Appl. Mech. Engrg.*, 2018
- Z. Lu, V. S. Arikatla, **Z. Han**, B. F. Allen, and S. De, A physics-based algorithm for real-time simulation of electrosurgery procedures in minimally invasive surgery, *Int. J. Med. Robot.*, 10(2014), 495-504
- L. Sun, J. Wand, **Z. Han**, and C. Zhu, Active Vibration Suppression Based on Intelligent Control for a Long-range Ultra-precise Positioning System, *Applied Mechanics and Materials*, 87(2011), 123-128

## Proceedings

- S. De, **Z. Han** and Rahul, A multi-physics model for radiofrequency ablation of soft tissue, *55th Society of Engineering Science Technical Meeting (SES 2018)*, 2018
- **Z. Han**, Rahul and S. De, An efficient solution approach for multiphysics modeling of electrosurgery, *13rd World Congress on Computational Congress (WCCM 2018)*, 2018
- **Z. Han**, Rahul, C. A. López, and S. De, A fast Krylov subspace-based method for multi-physics modeling of electrosurgical cutting of soft tissue, *VII International Conference on Coupled Problems in Science and Engineering*, Invited Sessions, 2017
- M. Dombek, C. A. López, **Z. Han**, D. B. Jones, J. Olasky, S. Schwaitzberg, C. Cao, S. De, The virtual electrosurgical skill trainer (VEST)- Face validation of a dispersive electrode placement module, Poster presentation at SAGES 2017 Annual Meeting; 2017 Mar. 22-25; Houston, TX.
- M. Dombek, C. A. López, **Z. Han**, D. B. Jones, J. Olasky, S. Schwaitzberg, C. Cao, S. De, The virtual electrosurgical skill trainer (VEST)- Principles of current pathway, Poster presentation at SAGES 2016 Annual Meeting; 2016 Mar. 16-19; Boston, MA.
- **Z. Han**, V. S. Arikatla, and S. De, A local level set-based approach for modeling electrosurgical tissue cutting, *13rd National Congress on Computational Mechanics*, Minisymposia, 2015
- **Z. Han**, V. S. Arikatla, and S. De, GPU-based parallel algorithms for simulation of Electrosurgery procedures in real-time, *13rd National Congress on Computational Mechanics*, Minisymposia, 2015
- X. Chen, S. Yang, and **Z. Han**, etc., Real-time, 3-dimensional scanning imaging system using tunable lens for dynamic precess, *Intelligent computation and Bio-Medical Instrumentation (ICBIM)*, *International conference on IEEE*, 2012