

# HANFENG ZHAI

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## EDUCATION

### Cornell University

M.S. in Mechanical Engineering

THESIS: *TBD*

ITHACA, NY

Sep. 2021 – June 2023

ADVISOR: Jingjie Yeo

### Shanghai University

B.S. in Theoretical and Applied Mechanics (*Outstanding Graduate of Shanghai*)

THESIS: *Predicting microbubble system dynamics with physics-informed deep learning*

SHANGHAI, CHINA

Sep. 2017 – June 2021

ADVISOR: Guohui Hu

## HONORS & AWARDS

**Outstanding Undergraduate Thesis Award**, Shanghai University

July, 2021

**Outstanding Graduate of Shanghai**, Shanghai Ministry of Education

May, 2021

**Second Class Award**, The 3rd Undergraduate Academic Forum of Shanghai University

Dec., 2020

**Outstanding Student Nomination**, Shanghai University

Dec., 2020

**Top Class Academic Scholarship**, Shanghai University

Nov., 2020

**Arts and Sports Scholarship**, Shanghai University

Nov., 2020

**Outstanding Undergraduate Course Project**, School of Mechanics and Engineering Science

Dec., 2019

**Third Place Award**, Shanghai University Body Building Contest

Apr., 2019

**Athletic Scholarship**, Shanghai University

Nov., 2018

**First Place Award**, Shanghai University Body Building Contest

Apr., 2018

**Outstanding Student**, Bank of China Life

Feb., 2018

**Team Award**, IBEP Financial Planning Competition

Feb., 2018

**Outstanding Student Nomination**, Shanghai University

July, 2018

## RESEARCH EXPERIENCES

### Summer Research Intern

Institute of Mechanics, Chinese Academy of Sciences

Supervisor: Xu Zheng

BEIJING, CHINA

May 2021 – Present

- Topic: Active particles in complex fluids

### Research Assistant

Shanghai Institute of Applied Mathematics and Mechanics

Supervisor: Guohui Hu

SHANGHAI, CHINA

May 2020 – July 2020

- Course projects: Apply linear regression algorithm to predict concrete strength [1]; decision tree algorithm to predict frigate propulsion velocity [2]; naïve Bayes classification for yacht hydrodynamics velocities [3].
- Designed and carried out bubbly flows numerical simulations with biomedical backgrounds in microscale with COMSOL Multiphysics.
- Initiated and proposed BubbleNet, a novel deep learning framework for inferring bubble dynamics with physics-informed neural networks, and open the project on GitHub [4], prove the effectiveness of BubbleNet [5].

### Scientific Editor Intern

QbitAI.com

BEIJING, CHINA

Jan. 2021 – Feb. 2021

- Translate research articles assigned by QbitAI instructors from *Nature*, *Science*, *PNAS*, & *Quanta*, *Phys.org*, etc.
- Wrote five scientific reporting articles on programmable meta-materials, physics-informed deep learning, etc. Assist with sorting out materials with other articles.
- QbitAI is one of the most influential online media on tech news in China. A Top 10 media on reporting research news, based on [2020 Annual Research Media Rankings](#).
- My articles reached 25600+ reads, with 150+ likes, which can be viewed at [1], [2], [3], [4], [5].

## Summer Research Intern

Shanghai University

Supervisor: Bingbing An

SHANGHAI, CHINA

Jun. 2020 – Aug. 2020

- Study and show that the plasticity properties of the peritubular dentin structure can effectively resist crack growth of the dentin based on numerical simulations. [\[Report\]](#)

## Research Assistant

Shanghai University & University of Washington

Supervisor: Dongsheng Zhang, Dwayne D. Arola

SHANGHAI & SEATTLE (Remote)

Sep. 2019 – Mar. 2020

- Carried out research in Arola Lab on enamel microstructure fracture resistance investigation and found that the band decussation can effectively resist fracture. [\[Project Page\]](#)
- Writing tech reports and doing presentations directly or remotely with the project principal Dwayne D. Arola.
- Carrying simulations and numerical analysis with Abaqus CAE & MATLAB based on the SEM photo of enamel microstructure to analyze the mechanical properties of enamel.

## EXTRACURRICULAR ACTIVITIES

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- **Student Athlete** at China University American Football League (CUAFL). Played Defensive End & Linebacker at *Shanghai University Bombers American Football Team* (2017 – 2019), won 3rd place twice in 2017 – 2018 & 2018 – 2019 seasons [\[Interview\]](#). Joined Russell Wilson football training camp as a DB. (July, 2018) [\[Media Coverage\]](#).
- **Member** of the Shanghai University Tulip Investment Club (2017 – 2018). Won Team Award & Outstanding Student at Financial Planning Competition hosted at Bank of China Life.
- **Member** of the Shanghai University Bodybuilding Contests (2017 – 2019). Won 1st & 3rd place in Shanghai University 2018 & 2019 Bodybuilding contest.

## SELECTED PROJECTS

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### Inferring Bubble Dynamics with Physics-Informed Deep Learning

Research project at Shanghai Institute of Applied Mathematics and Mechanics

Supervisor: Guohui Hu

Independent Researcher

Sep. 2020 – Present

- Carried out several microfluidic numerical simulation of bubbly flow based on the biomedical backgrounds.
- Implemented deep neural network to predict the physics fields (i.e., velocities, pressure, phase.) of the microfluids.
- Proposed a novel deep learning framework inspired by physics-informed neural network to predict bubbly flow and validate that the new framework can predict bubbly flow with higher accuracy.
- The source code can be downloaded through GitHub [\[1\]](#), and paper can be seen from arXiv [\[2\]](#).

### Fracture Resistance of Human Enamel Microstructure

Research project at Shanghai University

Supervisor: Dongsheng Zhang and Dwayne D. Arola

Group Member

Sep. 2019 – Mar. 2020

- Polished and etch the enamel specimen and observe enamel microstructure through SEM and took photos.
- Proposed a specific band structure based on the SEM photos for enamel microstructure.
- Verifies that the band structure can resist crack growth through simulations carried out by Abaqus CAE.

### Mechanical Properties of Biomaterials

Projects series on solid mechanics

Supervisor: Bingbing An

Independent Researcher

Apr. 2020 – Aug. 2020

- **Structural design of composite materials with superior mechanical behaviors: lesson from the microstructure of nacre and enamel** [\[Report\]](#)  
*Course project: CAD Application in Structural Mechanics*  
Designed a specific microstructure that displays higher fracture toughness and stiffness inspired from the microstructures of enamel and nacre.
- **Formulation and application of rate-independent stress update algorithm of hydrostatic pressure: elastoplastic yielding in composite.** [\[Report\]](#)  
*Course project: Plasticity Theory*  
Construct the constitutive model of fibre reinforced composite through rate-independent stress update algorithm, and estimate the fracture influence on the composite.

- **An investigation of the elastoplastic nature of ITD on the toughness of the dentin microstructure.** [\[Report\]](#)

*Shanghai University Summer Research Program*

Designed a specific microstructure that displays higher fracture toughness and stiffness inspired from the microstructures of enamel and nacre.

## Structural Design of Lightweight Compressive Layers

Team Leader

*Course project: Finite Element Method and Its Applications*

*Sep. 2019 – Dec. 2019*

Supervisor: Yicheng Song

- Designed different compression structures inspired from traditional Chinese arch bridge and truss structure.
- Built three models by CAD software and 3D printed them successfully.
- Repeated debugging before added a large metal block plate above the test piece to produce uniform loading, and then carried out loading on the test piece.
- Estimated the results of both experiments and simulations and proposed the best design of compressive interlayer.
- The project is nominated "**Outstanding Undergraduate Course Project**". The [poster](#) can be viewed on my page, which were displayed at the school hall.

## Thermal Estimation of Smartphone Chip

Independent Researcher

*Course project: Elastic Mechanics*

*Dec. 2019 – Mar. 2020*

Supervisor: Junqian Zhang

- Model the smartphone with ANSYS workbench with basic structure of battery and chip.
- Construct mathematical derivation and theoretical analysis of chip under thermal field adopting the theory of plate in multiphysics fields.
- Carried out thermal simulation with ANSYS and compare the results with theoretical results.
- Explain how the chip will change undergoes battery's thermal influence from both the results.
- The [tech report](#) can be viewed on my page, and I posted a [intro video](#).

## Design of Intelligent Tuning Equipment for Stringed Instruments

Project Principal

*National College Student Innovation and Entrepreneurship Project, No. 201910280001*

*Oct. 2019 – Aug. 2020*

Supervisor: Kai Li

- Modeled independently the integrated guitar structure, performed string vibration simulation in ANSYS and specified the effect of the guitar resonance cavity on the overall sound quality and the effect of pitch.
- Designed materials and fixtures according to the theoretical model, and settled on fixing the guitar strings by winding welding to minimize the measurement error under tension.
- Recorded accurately the experimental data, including frequency acquisition of recorded sounds with software.
- Instructed teammate with GUI programs and successfully imported data into MATLAB and Origin Pro for spectrum analysis.
- The details can be viewed on the [NCIE](#) website, the [report](#) and [poster](#) is available on my page.

## SOFTWARE

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### BubbleNet

A deep learning package for inferring microbubble dynamics with physics-informed neural networks.

**Environment:** Python, MATLAB, TensorFlow. [\[Website\]](#) · [\[Code\]](#) · [\[Paper\]](#) · [\[Video\]](#)

[MIT License](#) · DOI:10.5281/zenodo.4679081

## PUBLICATION

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1. **H. Zhai** and G. Hu\*. (2021) "Inferring micro-bubble dynamics with physics-informed deep learning". *arXiv preprint*. [arXiv:2105.07179](#).

## RESEARCH PRESENTATIONS

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1. **Computation Methods for Applied Mechanics Problem.** *The 3rd Undergraduate Academic Forum of Shanghai University*. Dec. 30th, 2020. [\[Poster\]](#) [\[Paper\]](#) [\[News\]](#)
2. **A brief introduction of deep learning algorithms applied to mechanics.** *Prof. Zhansheng Guo's Lab, Shanghai University*. Apr. 20th, 2021. [\[Slides\]](#)

## TECHNICAL SKILLS

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**Coding & Programming:** Python, MATLAB & Octave, Mathematica, C++, HTML, L<sup>A</sup>T<sub>E</sub>X, Bash, MPI, TensorFlow, PyTorch.

**Computer Systems:** Ubuntu, macOS, Windows 7 & 10.

**Simulation Softwares:** COMSOL Multiphysics, OpenFOAM, LAMMPS, ANSYS workbench & APDL, Abaqus CAE.

**Knowledge & Theories:** Computational Fluid Dynamics, Fluid & Solid Mechanics (Elasticity & Plasticity), Structural Mechanics, Machine Learning & Deep Learning, etc.

*Last update: July 6th, 2021*