

Hongxue Cai, Ph.D. (authorized to work in the United States)

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RESEARCH INTERESTS:

Mathematical modeling; auditory macro/micro/nano mechanics; biomathematics; mathematical physics; scientific programming; finite-element analysis and CFD; fluid-structure interactions in complex biological/mechanical systems; constitutive theory of living tissues; image processing; continuum modeling in biomedical/mechanical engineering; finite-deformation elasticity; cardiac mechanics and heart growth; (bio)fluid mechanics; analysis of the damage of mechano-sensory cells; tissue mechanics and growth; computer simulation in biomedical/mechanical engineering; mechanical coupling of vascular diseases; CAD software development; nanoindentation/contact mechanics

EDUCATION:

1995 - 1998: Ph.D. in Biomechanics, Laboratory of Composite Materials, University of Savoie, France

- **Dissertation:** Finite-deformation constitutive law for active myocardium: application to cardiac mechanics and to the growth of human fetal left ventricle
- **Supervisor:** Prof. Jacques Ohayon
- **Theory/technique:** continuum mechanics in curvilinear coordinates; perturbation methods; tensor calculus; finite difference; functional anatomy and physiology of human heart
- **Software:** Fortran; IMSL
- **Grade:** “very honorable,” along with congratulations of the defense committee (top 10% in French education system)

1984 – 1987: Master’s Degree of Engineering, Dalian Jiaotong University, China

- **Thesis:** Development of a CAD software package for the design of machine tool hydraulic systems
- **Theory/technique:** fluid mechanics; machine tool design; graphics library design; GUI development
- **Software:** C; AutoCAD; Autolisp
- **Grade:** A

1980 – 1984: Bachelor’s Degree of Engineering, Dalian University of Science and Technology, China.

WORK EXPERIENCE:

2004 - _____: NRC (National Research Council) Senior Research Associate, National Academy of Sciences, USA

- Research projects : (1) Numerical analysis of energy flow in the active mammalian cochlea.
(2) Effects of coiling on cochlear micromechanics
- Theory/technique:** WKB perturbation; finite-element analysis; sequential coupling theory of fluid-solid interactions; boundary layer theory; fluid dynamics; linear elasticity; partial differential equations; theory of plates; special functions
- Software:** C++, MATLAB PDE toolbox; Mathematica.

2000 - 2004: Visiting Fellow, Section on Auditory Mechanics, Laboratory of Cellular Biology, National NIDCD, NIH, USA

- Research project (1): Mathematical modeling of the dynamic fluid-structure interactions and vibratory patterns in the cochlea.
Theory/technique: hybrid WKB/finite-element; sequential coupling theory of fluid-solid interactions; boundary layer theory; fluid mechanics; linear elasticity; partial differential equations; plate Green's function
Software: MATLAB PDE toolbox; Mathematica; ANSYS Multiphysics/Flotran CFD
- Research project (2): Motion analysis in the hemicochlea
Theory/technique: incompressible optical flow; image processing technique;
Software: MATLAB image processing toolbox
- Participated project: Measurement of the material properties of the tectorial membrane using AFM
Theory/technique: Fourier transform; Hankel transform; potential theory; contact mechanics

1998 - 2000: Associate professor and director of the Computer Center of Mechanical Engineering department, Dalian Jiaotong University, China

- Establishment of the Computer Center (PC/Mac/SGI; C/C++, Fortran, AutoCAD, IDEAS, ANSYS, FEA/CAD/CAM/CAE/VM)
- Courses taught: FEA; mechanical CAD/CAM; fluid mechanics; biomechanics
- Supervision and speeding up of research projects of graduate students in mechanical engineering
- Research projects: CAPP software development; Biomechanical model of the coarctation of aorta
- Computer administration using command lines (not just point and click)

1990 - 1994: Lecturer and Head of the Laboratory of Hydraulic Transmission and Control, Dept. of Mechanical Engineering, Dalian Jiaotong University, China

- Courses taught: machine tool design; fluid mechanics; scientific English; control theory
- Supervision of practical projects of undergraduate students in mechanical engineering
- Research projects: CAD /CAPP software development: C/C++. Large-scale software development -- GUI / Database / graphics library / Chinese keyboard development

1987 - 1990: Lecturer, Section on Manufacturing Automation, Dept. of Mechanical Engineering, Dalian Jiaotong University, China.

SELECTED RECENT PUBLICATIONS:

Journals and book chapters:

- Cai, H.**, Shoelson, B and Chadwick R.S., Evidence of tectorial membrane radial motion in a propagating mode of a complex cochlear model, *Proc. Natl. Acad. Sci. USA*, 101(16):6243-6248, 2004.
- Shoelson, B., Dimtriadis, E. **Cai, H.**, Kachar, B and Chadwick, R., Evidence and implications of inhomogeneity in tectorial membrane elasticity, *Biophys. J.*, 87:2768-2777, 2004.
- Chadwick R.S., Shoelson, B. and **Cai, H.**, Surface Green's functions for an incompressible, transversely isotropic elastic half-space, *SIAM J. Appl. Math.*, 64(4):1186-1197, 2004.
- Cai, H.** and Chadwick, R.S., Radial structure of traveling waves in the inner ear, *SIAM J. Appl. Math.*, 63(4):1105-1120, 2003.
- Cai, H.**, Richter, C.P. and Chadwick, R.S., Motion analysis in the hemicochlea, *Biophys. J.*, 85:1929-1937, 2003.
- Cai, H.** and Chadwick, R.S., Computation of modes and motion analysis in a transverse section of the cochlea, in: Gummer, A.W. (Ed.), *Biophysics of the Cochlea, from Molecules to Models*, World Scientific, Singapore, 2003, pp. 400-408.
- Ohayon, J., **Cai, H.**, Jouk P.S., Usson, Y. and Azancot, A., A model of the structural and functional development of the normal human fetal left ventricle based on a global growth law, *Computer Methods in Biomechanics and Biomedical Engineering*, 5(2):113-126, 2002.
- Ohayon, J., **Cai, H.**, Usson, Y. Jouk P.S. et Azancot, A., Loi de comportement d'un tissu vivant: application a la mecanique du Coeur fetal humain, in: Gamac, *Mecano Transduction, materiaux et structure des sciences de l'ingenieur et du vivant*, Paris, France, 2000.
- Ohayon, J., Usson, Y., Jouk P.S., **Cai, H.**, Fiber orientation in human fetal heart and ventricular mechanics: a small perturbation analysis. *Computer Methods in Biomechanics and Biomedical Engineering*, 2:83-105, 1999.
- Cai, H.**, Usson, Y., Jouk, P.S., Ohayon, J., Fiber orientation in mid-gestation human fetal heart and ventricular mechanics, *Innovation and Technology in Biology and Medicine*, 20(2):67-83 , 1999.
- Kong, X., **Cai, H.**, An algorithm for finding the convex hulls of simple polygons using active double-line testing, *Journal of Computer*, 8:596:600, 1994.
- Cai, H.**, Li, M. and Kong, X., CAD software package for the design of hydraulic equipments of allied machine tools, *Allied Machine Tools and Automation Technology*, 1:15-16, 1993.
- Cai, H.**, Yu, X. and Lu, T., Development of CAPP software for heat treatment, *Academic J. of Dalian Railway Institute of Technology*, 2:49-52, 1993.
- Cai, H.**, Zhang, S. and Jiang, H., Computer system for managing seaport equipments, *Equipment Management and Maintenance*, 6:8-9, 1992.

International conferences:

- Cai, H.**, Shoelson, B., Chadwick, R.S., Shear gain and tectorial membrane vibratory patterns at the basal and apical regions of the cochlea, *27th ARO Midwinter meeting*, Florida, USA, 2004
- Shoelson, B., Dimitriadis, E.K., **Cai, H.** and Chadwick, R.S., Theoretical and experimental considerations for the study of anisotropic elastic moduli of the mammalian tectorial membrane, *26th ARO Midwinter meeting*, Florida, USA, 2003
- Cai, H.**, Richter, C.P., Chadwick, R.S., A new approach for optical flow analysis of cochlear motions, *25th ARO MidWinter meeting*, Florida, USA, 2002, pp.237
- Cai, H.**, Chadwick, R.S., A new micromechanical model for the radial vibrational modes in the mammalian cochlea, *25th ARO MidWinter meeting*, Florida, USA, 2002, pp.236
- Ohayon, J., Usson, Y., Jouk, P.S., **Cai, H.**, Azancot, A., Structural and functional development of the normal human fetal left ventricle: inference in the performance analysis of hypoplastic right ventricle hearts, *5th International Symposium on Computer method in Biomechanics and Biomedical Engineering*, Rome, Italy, 2001
- Cai, H.**, Chadwick, R.S., Toward a computational model of the radial structure of the cochlear traveling waves, *24th ARO MidWinter meeting*, Florida, USA, 2001, pp.231
- Ohayon, J., **Cai, H.**, Jouk, P.S., Usson, Y., Azancot, A., A model for the growth of the human fetal left ventricle. *XXIVeme Congres de la Societe Biomecanique*, Beaune, France, 1999
- Cai, H.**, Ohayon, J., Azancot, A., Oddou, C. An anisotropic model for stress induced growth in human fetal heart, *Third World Congress of Biomechanics*, Sapporo, Japan, 1998
- Azancot, A., Ohayon, J., **Cai, H.**, Model for stress induced growth in human fetal heart, *XXIII meeting of Association of European Pediatric Cardiologists*, Dublin, Ireland, 1998

Talks:

- Annual conference of the American Society of Biomechanics (ASB), Portland, Oregon, September 11, 2004.
- Department of Mathematical Sciences, New Jersey Institute of Technology, Newark, April 29, 2004.
- School of Biomedical Engineering, Science and Health systems, Drexel University, Philadelphia, April 8, 2004.
- BMES 2003 Annual Fall Meeting, Nashville, TN, Oct. 3, 2003.
- 26th ARO Midwinter meeting, Florida, USA, Feb. 26, 2003.
- International Symposium on Biophysics of the Cochlea, Titisee, Germany, 2002
- National Institute on Deafness and Other Communication Disorders, Bethesda, MD, May 5, 2002.

GRANTS AND CONTRACTS:

- Biomechanical model of the coarctation of aorta, *Ministry of Education, China*, 1999. ¥30,000
- Development of CAPP software, *Department of Science and Education, Dalian, China*, 1999. ¥100,000
- Computer management system for the maintenance of seaport equipments, *Seaport of Dalian, Dalian, China*, 1994. ¥50,000
- Development of CAD software package for the design of machine tool hydraulic systems, *Dalian Machine tool factory, Dalian China*, 1989. ¥20,000

HONORS AND AWARDS:

- NRC Senior Research Associate Award, National Research Council, USA, 2004
- Fellows Award for Research Excellence, National Institutes of Health (NIH), USA, 2004
- Visiting Fellowship, National Institutes of Health (NIH), USA, 2000-2004
- Ph.D. Scholarship (in France), Department of Education, China, 1994-1998, **Grade:** “very honorable,” along with congratulations of the defense committee (top 10% in French education system)
- 2nd grade “Scientific and Technical Progress Prize,” Liaoning, China, 1994
- 1st grade Research Excellence Award, Dalian Railway Institute, China, 1993
- One of the "One Hundred Outstanding Young Scientists," Liaoning, China, 1992
- “Teaching Excellence Award,” Dalian Jiaotong University, China, 1992
- 2nd grade “Computer Application Prize,” Dalian, China, 1992
- 3rd grade “Scientific and Technical Progress Prize,” Dalian, China, 1989
- 2nd place in the “Institute Oral English Competition”, Dalian Railway Institute, China, 1988

OTHERS:

- **Review of papers** for JASA, Physical Review Letters, Biophysical J., SIAM J. Appl. Math.(2)
- **Supervisor** of graduate students in mechanical engineering
- **Member** of Association for Research in Otolaryngology
- **Software skills:** C/C++, Fortran, MATLAB (PDE, Image Processing Toolbox), ANSYS (Multiphysics), AutoCAD, IDEAS, Pro/E, Latex, Adobes, Microsoft Office, Database
- **Languages:** English, French, Chinese
- **Books read since 2000:**
 - Green and Zerna, Theoretical Elasticity, Oxford.
 - Fung, Foundation of Solid Mechanics, Prentice Hall.
 - Morse and Feshbach, Methods of theoretical Physics, Mc Graw-Hill Book Company.
 - Sneddon, Fourier Transform, Dover.
 - Timoshenko and Goodier, Theory of Elasticity, Mc Graw-Hill Book Company.
 - Happel and Brenner, Low Reynolds Number Hydrodynamics, Prentice Hall.
 - Love, A Treatise on the Mathematical Theory of Elasticity
 - Fung, Biomechanics: Motion, flow, stress and growth, Springer-Verlag
 - Fung, Biodynamics: Circulation, Springer-Verlag ...