

Curriculum Vitae

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Personal Data

Name: **Madhusudhan Venkadesan**

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Current Position

June 2008 – Present: Postdoctoral Fellow
School of Engineering & Applied Sciences
Harvard University.

Professional Areas of Interest

Dynamics of biomechanical systems, Multibody dynamics, Multisensory control, Optimal control, Model reduction, Neuromuscular biomechanics, Sensorimotor Control, Bifurcation theory, Stochastic dynamical systems, Delay differential equations, Clinical measurement and evaluation of motor function, Nonlinear dynamical systems.

Educational Background

Ph.D. January, 2007
Cornell University
Sibley School of Mechanical & Aerospace Engineering
Minor field: Applied Mathematics

M.S. July, 2003
Cornell University
Sibley School of Mechanical & Aerospace Engineering
Specialization: Dynamics, Systems and Control / Biomechanical Engineering

B. Tech. June, 2000
Indian Institute of Technology (IIT), Madras
Major: Mechanical Engineering
Specialization: Manufacturing Engineering

Teaching Positions

- 2002 – 2003: **Teaching Assistant**
Sibley School of Mechanical & Aerospace Engineering, Cornell University
MAE 463: Neuromuscular Biomechanics, Spring 2002, Spring 2003
MAE 479/579: Analysis and Simulation of Mechanical and Aerospace Systems, Fall 2003
MAE 326: System Dynamics, Spring 2004
Lab Instructor
ENGRG 606: Electromyography Laboratory, Spring 2002, 2003
- Guest lectures: Sibley School of Mechanical & Aerospace Engineering, Cornell University
MAE 479/579: Fall 2006: lecture on 3-D rotations
MAE 463: Spring 2007: lecture on kinematic chains.
- School of Engineering & Applied Sciences, Harvard University
APMTH 115: Fall 2008: lectures on ‘Mechanical random number generators’, ‘Errors and strategies’, ‘Voting systems: political strategies’

Research Positions

- June 2008 – Present: Postdoctoral Fellow
School of Engineering & Applied Sciences
Harvard University
- Aug 2007 – May 2008: Postdoctoral Associate
Department of Mathematics
Cornell University
- Sep 2006 – Aug 2007: Postdoctoral Associate
Neuromuscular Biomechanics Laboratory
Cornell University
- November 2005: Visiting pre-doctoral student
Max Planck Institute for Human Cognitive and Brain Sciences
Munich, Germany.
- Aug 2000 – Jan 2007: Graduate Research Assistant, Doctoral Program
Neuromuscular Biomechanics Laboratory
Cornell University.

1999 – 2000	Indian Institute of Technology, Madras Final Year Project: <i>A study on the use of explicit time integration methods for metal forming simulations</i>
1998	Summer Intern Indira Gandhi Centre for Atomic Research, Kalpakkam Summer Project: <i>Plastic Collapse Load Analysis of Pipe Bends</i>

Research Support

Grant Writing Experience

2007 (unsuccessful)	Principal Investigator , “Neuromechanics of bipedal balance control in humans” Helen Hay Whitney Foundation Goal: To characterize the effects of passive dynamics and hybrid continuous-discrete control strategies on balance control in humans.
2004 – 2008	Co-author as graduate student, “Control of Finger Motion and Force for Precision Pinch” \$915,050 total cost National Institutes of Health, R01 Priority score 132; Percentile priority score: 0.8%. Currently funded. Goal: To describe and explain how the musculature of the index finger is coordinated to orchestrate fingertip motion and force, a fundamental requirement of dexterous manipulation. Dr. Francisco J. Valero-Cuevas, PI.
2004 – 2007	Co-author as graduate student, “Developing a Clinically Useful Measure of Dynamic Pinch” \$383,722 total cost National Institutes of Health, R21 Priority score 163; Percentile priority score: 12.8%. Currently funded. Goal: To provide a much-needed simple, valid, and reliable measure of dynamic thumb forces that quantifies functional performance, impairment and recovery related to orthopedic and neurological diseases. Dr. Francisco J. Valero-Cuevas, PI.

Engineering Experience

Mechanical Design Experience

2007	A mechanical locomoting device and a robotically controlled split-treadmill for data-driven characterization of legged locomotion.
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| 2001 | A testing system to measure dynamic pinch performance (US Patent Pending). |
| 1998 | A computer controlled automatic feedback system for temperature regulation of a fluid filled container. |

Computer Related Experience

Network Administration

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| 2000 – 2003 | Network administrator at the Neuromuscular Biomechanics Laboratory, Cornell University. Windows NT/2000/XP, Red Hat and SUSE Linux, Mac OS 9.1, Mac OS X |
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Computer Aided Design / Computer Simulation of Mechanical Systems

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| 2004 | Designed and manufactured end caps for use in a device to measure dynamic pinch performance using a 3D printer (Stratsys FDM3000). |
| 2003 | Deployed an online trebuchet simulator, and online Pareto front as teaching assistant for MAE479/579, Cornell University. |
| 1999 – 2000 | Developed FEM code for contact simulation in metal forming processes using Fortran, IIT Madras. |
| 1998 | Developed a 3D FEM model of pipe bends using ABAQUS for plastic collapse load analysis of coolant pipes in Fast Breeder Reactors, Indira Gandhi Centre for Atomic Research, Kalpakkam. |
| 1997 | Implemented anti-windup strategies for PID controllers in MATLAB for ME322, Control Systems, IIT Madras. |

Programming Languages

MALTAB, SIMULINK, LabView, IGOR, C, C++, Fortran, Pascal, Perl, XHTML, Python

Operating Systems

Windows 95/98/NT/2000/XP, Unix (Linux, IRIX, AIX), Mac OS 9.1, OS X

Other Application Packages

ABAQUS, ANSYS, IDEAS

Awards & Distinctions

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| 2007 | Article titled, “Manipulating the edge of instability”, was third in the list of <i>Top 25 Most Downloaded Articles of the Journal of Biomechanics</i> for the |
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period April – June 2007.

2006	Winner, 2006 <i>Journal of Biomechanics Award</i> of the American Society of Biomechanics.
2005	Featured in “ <i>Discovery to Recovery</i> ”, research newsletter of the Hospital for Special Surgery, New York, NY.
2004	The Sibley School Exceptional Teaching Assistant Award, Cornell University.
2002 – 2005	Featured in the “ <i>Ask an Engineer</i> ” traveling interactive show “Tech City” sponsored by the National Science Foundation.
2000 – 2001	Sage Fellowship Award to begin Doctoral Studies, Cornell University.
2000 – 2001	Engineering Supplementary Fellowship Award, Cornell University.
1999	Runner up in a National Scrabble contest, Saarang 1999, IIT Madras.
1996	Ranked 491 in the Joint Entrance Examination (an national exam for admission to the IITs, written by approx. 100,000 candidates.)
1996	Ranked 21 in the National Level Physics Talent Search Exam held by the Indian Physics Society.
1994	Ranked 41 in the Indian National Mathematical Olympiad.

Scientific Development

2008	Participant in <i>Neuromechanics of Locomotion</i> workshop at the Mathematical Biosciences Institute, Columbus, OH.
2008	Participant in <i>Biomechanics and Neural Control - Muscle, Limb, and Brain</i> workshop at the Mathematical Biosciences Institute, Columbus, OH.
2007	Participant in <i>A Day of Locomotion</i> , a workshop on biological locomotion at Harvard University, Cambridge, MA.
2007	Participant in <i>Behavioral & Cognitive Dynamical Systems Workshop</i> , on the role of dynamical systems in characterizing phenomena in human behavior and cognition at Cornell University, Ithaca, NY.
2004	Participant in the <i>First Motor Control Summer School</i> at Jim Thorpe, PA.

- 2002 Participant in the *Neural Engineering Summer Course, 2002* sponsored by the National Science Foundation at the Neurosciences Institute, La Jolla, CA.
- 2002 Intern at the Hospital for Special Surgery summer *Immersion* program, sponsored by the Cornell University – Hospital for Special Surgery Biomechanics Program, held at HSS, New York, NY.
- 2001 Participant in the 4th Workshop on Nonlinear Dynamics and Chaos at the Courant Institute of Mathematical Sciences, New York, NY.

Journal Reviewer

Journal of Neurophysiology, Journal of Theoretical Biology, IEEE Transactions on Systems, Man, and Cybernetics, IEEE Transactions on Biomedical Engineering, Physics Letters A, Integrative & Comparative Biology, Journal of Applied Physiology, Medical and Biological Engineering and Computing

Grant Reviewer

U.S. Air Force Office of Scientific Research, Directorate of Mathematics, Information and Life Sciences.

Professional Membership

American Society of Biomechanics
Society for the Neural Control of Movement
Society for Integrative & Comparative Biology
American Society of Mechanical Engineers
International Society of Biomechanics
Society for Neuroscience

University Service

- 2007 Co-organized the Cornell Mathematical Contest in Modeling 2007, in which a team of three undergraduates tackles an open-ended (“real-world”) problem, builds a mathematical model, obtains a solution based on it, and writes a detailed paper:
<http://www.math.cornell.edu/~mcm>
- 2002 – 2003 Co-organized seminar series for the *Machines and Organisms: Locomotion and Manipulation*, an interdisciplinary research lecture series, now sponsored by “IGERT: Program in Nonlinear Systems” (previously known as *Animal Coordination Seminar*), Cornell University.

2001 – 2002	President, International Students' Programming Board (ISPB) - a funding organization for student groups at Cornell University.
2000 – 2001	Board Member, ISPB, Cornell University.
2000	Main quiz coordinator, Shaastra 2000, IIT Madras.
1999	Co-organized a National Symposium on topics in Mechanical Engineering at the Graduate / Undergraduate level as part of Shaastra 1999, IIT Madras.
1998	Professional Shows Volunteer, Saarang 1998, IIT Madras.
1996 – 2000	Student Secretary, Mechanical Engineering Association, IIT Madras.

Publications

Dissertations & Thesis

Ph.D. Thesis (2007) *Dynamic dexterous manipulation: Benefits of the edge of instability in exploring complex dynamical behavior.*

Sibley School of Mechanical & Aerospace Engineering
Cornell University, Ithaca, NY, U.S.A.

B Tech Thesis (2000) *A study on the use of explicit time integration methods for metal forming simulations.*

Department of Mechanical Engineering
Indian Institute of Technology, Madras, India.

Peer-reviewed Articles

1. Valero-Cuevas FJ, Smaby N, **Venkadesan M**, Peterson M, Wright T. The Strength-Dexterity test as a measure of dynamic pinch performance. *Journal of Biomechanics*, 2003;36(2): p. 265-270. doi:10.1016/S0021-9290(02)00340-8.
2. **Venkadesan M**, Guckenheimer J, Valero-Cuevas FJ. Manipulating the edge of instability. *Journal of Biomechanics*, 2007;40(8): p. 1653-1661. doi:10.1016/j.jbiomech.2007.01.022. 2006 Journal of Biomechanics Award Paper.
3. **Venkadesan M**, Valero-Cuevas FJ. Neural control of motion-to-force transitions with the fingertip. *Journal of Neuroscience*, 2008;28(6): p. 1366-1373. doi:10.1523/jneurosci.4993-07.2008.
4. **Venkadesan M**, Valero-Cuevas FJ. Effects of neuromuscular lags on controlling contact transitions. *Philosophical Transactions of the Royal Society A*, In press.

Manuscripts in Review

1. Todorov E, **Venkadesan M**, Valero-Cuevas FJ. Structure in the variability of muscle activations. Journal: *Journal of Neurophysiology*.
2. **Venkadesan M**, Mahadevan L. How to throw accurately. Journal: *Proceedings of the National Academy of Sciences*.
3. Mosier K, Lau C, Wang Y, **Venkadesan M**, Valero-Cuevas FJ. Cortical networks for the control of hand dexterity. Journal: *Journal of Neurophysiology*.

Manuscripts in Preparation

1. **Venkadesan M**. Dynamics make biomechanical models stronger. Target journal: *Journal of Biomechanics*.
2. **Venkadesan M**, Backus S, Mandl LA, Valero-Cuevas FJ. The strength-dexterity test is a quick and clinically informative measure of treatment outcome in thumb osteoarthritis. Target journal: *Journal of Biomechanics*. (Dissertation Chapter IV)
3. Medina FA, McNamara III RV, **Venkadesan M**, Santos VJ, Song S, Grace-Martin K, Valero-Cuevas FJ. The nervous system transitions rapidly between incompatible motor control strategies by selectively exploiting the margins of error of the task. Target journal: *Journal of Neurophysiology*.
4. **Venkadesan M**, Guckenheimer J, Valero-Cuevas FJ. Does the inertia of kinematic chains significantly affect their dynamics?. Target journal: *Journal of the Royal Society Interface*.

Invited Symposia

1. Backus S, **Venkadesan M**, Mandl LA, Valero-Cuevas FJ. Development of a clinically useful measure of dynamic pinch. NICHD Outcomes Measurement Meeting. Rockville, Maryland. December 9, 2005
2. **Venkadesan M**, Valero-Cuevas FJ, Guckenheimer JM. The boundary of instability as a powerful experimental paradigm for understanding complex dynamical sensorimotor behavior: Dexterous manipulation as an example. In Advances in Computational Motor Control II. Symposium at the 33rd Annual Meeting of the Society for Neuroscience. New Orleans, LA, 2003.

Invited Seminars

1. “Dexterous manipulation in humans: Characterizing a noisy dynamical system”, Dynamical Systems / Nonlinear Science Seminar, The Program in Applied and Computational Mathematics, Princeton University, Princeton, NY. 2006.

2. “Sensorimotor Integration in Humans: Characterizing a Noisy Dynamical System”, Dynamical Systems Seminar, Department of Mathematics, Cornell University, Ithaca, NY. 2005.
3. “Dynamic Manipulation in Humans: Quantification and Characterization”, Mechanical Engineering Seminar, Indian Institute of Science, Bangalore. 2005.
4. “Exploring the Continuum of Mixtures of Feedback and Feedforward Controllers at the Boundary of Instability During Dynamical Dexterous Manipulation”, Mechanical & Aerospace Engineering seminar, University of Florida, Gainesville, FL. 2005.

Peer-reviewed Conference Proceedings Abstracts

1. **Venkadesan M**, Mahadevan L. How to throw accurately. *Proceedings of the 2009 Annual Meeting of the Society for Integrative and Comparative Biology*, Boston, MA. January 3-7, 2009. Abstract no. P3.70. 2009.
2. **Venkadesan M**, Mosier K, Lau C, Wang Y, Valero-Cuevas FJ. Cortical networks for controlling instabilities in dexterous manipulation. *Proceedings of the 31st Annual Meeting of the American Society of Biomechanics*, Palo Alto, CA. August 22-25, 2007. Abstract no. 459. 2007.
3. Backus SL, Keenan K, McNamara III RV, Medina FA, Song S, Price C, Valero-Cuevas FJ, **Venkadesan M**. The transition between muscle coordination patterns is context dependent. *Proceedings of the 31st Annual Meeting of the American Society of Biomechanics*, Palo Alto, CA. August 22-25, 2007. Abstract no. 457. 2007.
4. **Venkadesan M**, Guckenheimer J, Valero-Cuevas FJ. Dynamic multisensory integration at the edge of instability is explained by a simple data-based model. *Proceedings of the 30th Annual Meeting of the American Society of Biomechanics*, Blacksburg, VA. September 6-9, 2006. Abstract no. 189. 2006.
5. **Venkadesan M**, Srinivasan M, Guckenheimer J, Valero-Cuevas FJ. The interplay of sensorimotor time-delays and noise in multisensory integration. *Proceedings of the World Congress of Biomechanics*, Munich, Germany. 2006, July 29 - August 4, 2006: *Journal of Biomechanics* 2006; Vol. 39 Suppl. 1, p. S98.
6. Valero-Cuevas FJ, McNamara III RV, Santos VJ, **Venkadesan M**, Song S, Grace-Martin K. The nervous system transitions rapidly between incompatible control strategies by predictively exploiting the margins of error of the task. *Proceedings of the World Congress of Biomechanics*, Munich, Germany. 2006, July 29 - August 4, 2006: *Journal of Biomechanics* 2006; Vol. 39 Suppl. 1, p. S95.
7. Medina FA, McNamara III RV, Backus SL, **Venkadesan M**, Santos VJ, Valero-Cuevas FJ. Muscle redundancy enables the transition between, and adjustments of, complex motor tasks. *Proceedings of the World Congress of Biomechanics*, Munich, Germany, July 29 - August 4, 2006: *Journal of Biomechanics* 2006; Vol. 39 Suppl. 1, p. S33.

8. Medina FA, McNamara RV III, Backus SL, **Venkadesan M**, Santos VJ, Valero-Cuevas FJ. Muscle redundancy: tool or trouble? *Proceedings of the Sixteenth Neural Control of Movement Annual Meeting*, Key Biscayne, FL. Poster Session 1. Limb Motor Function: Synergies, Poster No. D-04 (no page number provided in program), May 5, 2006.
9. **Venkadesan M**, Srinivasan M, Guckenheimer J, Valero-Cuevas FJ. Computational time-delays due to sensory processing affect multisensory integration strategies. *Proceedings of the Neural Control of Movement Annual Meeting*, Key Biscayne, FL. Session 2, Poster No. G-09 (no page number provided in program), May 4, 2006.
10. **Venkadesan M**, Backus S, Mandl LA, Swigart A, Peterson M, Lyman S, Ariola L, Hotchkiss RN, Valero-Cuevas FJ. The strength-dexterity test is a novel and clinically informative measure of treatment outcome in thumb osteoarthritis. *Arthritis and Rheumatism*, 2005;52(9):S516, 1362 Suppl. S. Presented at the 2005 Annual Scientific Meeting of the American College of Rheumatology, November 12-17, 2005. San Diego, California.
11. **Venkadesan M**, Roach S, Guckenheimer J, Valero-Cuevas FJ. The continuum of mixtures of feedback and feedforward control strategies used in dynamical dexterous manipulation can be explored at the boundary of instability. *Joint proceedings of the 20th Congress of the International Society of Biomechanics and the 29th Annual meeting of the American Society of Biomechanics*, Cleveland, OH. Musculoskeletal Modeling podium session, July 31 - August 5, 2005. p. 811.
12. Mosier K, **Venkadesan M**, Lau C, Wang Y, Valero-Cuevas FJ. Cortical modulation of dynamic sensorimotor integration: an investigation of pinch force vs. stability in the hand. *Proceedings of the Neural Control of Movement Annual Meeting*, Key Biscayne, FL. April 2005.
13. Ashley DA, **Venkadesan M**, Santos VJ, McNamara RV, Valero-Cuevas FJ. Competing constraints in hybrid force-motion tasks may lead to a severe reduction of maximum voluntary force magnitudes. *Proceedings of the Fifteenth Neural Control of Movement Annual Meeting*, Key Biscayne, FL, April 2005.
14. Valero-Cuevas FJ, Santos VJ, **Venkadesan M**, Song S. During abrupt transitions from finger motion to static force, errors in force direction are tuned to exploit the allowable margin of error afforded by surface friction. *Proceedings of the 5th Triennial International Hand & Wrist Biomechanics Symposium*, Syracuse, NY. 2004.
15. **Venkadesan M**, Guckenheimer JM, Valero-Cuevas FJ. Introducing a quick evaluation of sensorimotor integration in precision pinch. *Proceedings of the 5th Triennial International Hand & Wrist Biomechanics Symposium*, Syracuse, NY. 2004.
16. **Venkadesan M**, Valero-Cuevas FJ, Guckenheimer JM. The dynamic sensorimotor regulation of fingertip force vectors is independent of hand strength. *Proceedings of the 27th Annual Meeting of the American Society of Biomechanics*, Toledo, OH. 2003.

17. **Venkadesan M**, Valero-Cuevas FJ, Smaby N, Pretz J, Ramakrishna K, Wilson N, Skaliotis J and Peterson M. The strength-dexterity test as a measure of dynamic pinch performance. *Proceedings of the Neural Control of Movement Annual Meeting*, Santa Barbara, CA. 2003.
18. Valero-Cuevas FJ, Talati A, **Venkadesan M**, Hirsch J. How networks of cortical activity adapt in response to changes in type and quality of sensory input during precision pinch. *Proceedings of the Neural Control of Movement Annual Meeting*, Santa Barbara, CA. 2003.
19. Valero-Cuevas FJ, **Venkadesan M**, Talati A, Hirsch J. How networks of cortical activity adapt in response to changes in type and quality of sensory input during precision pinch. *The Second World Congress of Biomechanics*, Calgary, Alberta. 2002.
20. Valero-Cuevas FJ, Smaby N, **Venkadesan M**, Peterson M, Wright T, Hotchkiss R, Backus S, Ariola LA. The strength-dexterity test as a measure of pinch performance in hands with able and osteoarthritic thumbs. *Proceedings of the 57th Annual Meeting of the American Society for Surgery of the Hand*, Baltimore, MD. 2002.
21. Valero-Cuevas FJ, Smaby N, **Venkadesan M**, Pretz J, Ramakrishna K, Wilson N, Skaliotis J, and Peterson M. The strength-dexterity test as a measure of pinch performance in the able and impaired hand. *Proceedings of the 25th Annual Meeting of the American Society of Biomechanics*, San Diego, CA. 2001.

Abstracts

1. **Venkadesan M**, Valero-Cuevas FJ, Guckenheimer JM. The dynamic sensorimotor regulation of fingertip force vectors is independent of hand strength. 33rd Annual Meeting of the Society for Neuroscience. New Orleans, LA. 2003.
2. Valero-Cuevas FJ, **Venkadesan M**, Talati A, Hirsch J. How networks of cortical activity adapt in response to changes in the type and quality of sensory input during dynamic precision pinch. 32nd Annual Meeting of the Society for Neuroscience. Orlando, FL. 2002.

Other

Languages

English, Tamil, Hindi