Nikunj Bhagat

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Education

- **Ph.D.** in Electrical Engineering, University of Houston, Houston, TX, 2017
  Dissertation – Brain-machine interface (BMI) with closed-loop neuromuscular stimulation to restore grasping in stroke and spinal cord injury survivors.
  Adviser – Jose Contreras-Vidal, Ph.D.
  GPA – 3.85/4

- **M. Tech** in Electrical Engineering, Indian Inst. of Tech. Bombay, Mumbai, India, 2011
  Thesis – Sensing and cancelling of tremors in a surgeon's hands during microsurgery.
  Advisers – Prasanna Gandhi, Ph.D. and Debraj Chakraborty, Ph.D.
  CPI – 9.1/10

- **B. E.** in Electronics Engineering, Sardar Patel College of Engg., University of Mumbai, Mumbai, India, 2007
  Division – First Class (65%)

Experience

- Assistant Professor & Ramalingaswami Fellow, Indian Institute of Technology Kanpur
  Departments of Electrical Engineering, Biological Sciences & Bioegg. (joint appointment)
  Dec 2023 – Present
  o *Research Areas:* Neural & Bio-signal processing, Medical Instrumentation, Brain-machine interfaces, Functional Electrical Stimulation, and Rehabilitation Engineering

- Ramalingaswami Faculty Fellow, Dept. of Electrical Engg., Indian Institute of Science
  Mar – Oct 2023
  o Awarded Dept. of Biotechnology's prestigious Ramalingaswami Re-entry Fellowship for 5 years with ₹50 lacs research funding and ₹73 lacs for salary & overheads.
  o Research into EEG's applicability as a feedback signal for realizing closed loop neurostimulation systems was explored.

- Adj. Asst. Professor, Dept. of Physical Med. & Rehab., Univ. of Texas Health Sci., TX, US
  Sept. 2021 – Aug. 2023
  o Offered seminars on specialized research topics for post-doctoral researchers and clinicians
  o Conceptualized and commercialized 'NeuroStimDuino' – an open source neurostimulator for students, researchers, and hobbyists interested in neuroscience.
  o Raised more than $12k on crowd-funding site Crowd Supply and sold 100 units.

- Nidhi Prayas Awardee, Dept. of Science & Technology & SCTIMST, Trivandrum, IN

Jun. 2021 – Nov. 2022
- o Developed a novel hand rehabilitation therapy for training and assessing motor recovery (using computer vision) in patients with stroke and spinal-cord injury
- o Received ₹10 lacs funding from Dept. of Science & Technology, Govt. of India under the NIDHI-PRAYAS (Promoting & Accelerating Young & Aspiring Innovators & Startups) initiative
- o Follow-on funding for ₹10 lacs received from BIRAC under the Amrit Grand Challenge award for Digital Healthcare

- Electrical Engineer, Feinstein Institutes for Medical Res., Northwell Health, NY, USA
  Apr. 2019 – Apr. 2021
  - o Led the development of a flexible, programmable electrode array to deliver neuromuscular stimulation and restore dexterous hand movements in patients with paralysis.
  - o Engaged in conducting clinical research to test the efficacy of neuromuscular stimulation and brain-machine interfaces for hand rehabilitation in patients with spinal-cord injury.
  - o Developed a wearable, wireless, multi-joint position and force measurement glove using bend, flex and IMU sensors and 3D-printed contraptions to precisely record electrically stimulated hand movements.
  - o Designed BMI experiments for recording and decoding neural signals (LFP, multi-unit activity) from cortically implanted microelectrodes, ECoG, and stereo EEG electrodes in humans.
  - o Performed vagus nerve stimulation studies in acute swine models, as a treatment for acid reflux or GERD
  - o Prepared grants for submission to DoD and NY State's Spinal Cord Injury Research awards, clinical translation award from Wings for Life foundation and received positive feedback from reviewers. Our lab received NY State's SCI research award for $3.6Mn in Nov' 2022

- Biomedical Engineer, Neuro-Regeneration, Houston Methodist Research Inst., Houston
  Jan. 2018 – Apr. 2019
  - o Led the prototype development and preclinical validation of a trans-tracheal vagus nerve stimulator, to induce neuroprotection during acute stroke recovery.
  - o Performed high-resolution electrophysiology recordings and analysis of evoked compound action potentials and motor potentials, recruitment curves, etc.
  - o Setup an electrophysiology and electronics lab from ground up for rapid prototyping; developed a transparent process to vet vendors and negotiated vendor contracts.

- Graduate Research Assistant, Electrical & Comp. Engg., Univ. of Houston, Houston, TX
  Sept. 2012 – Jan. 2018
  - o Performed system integration, data collection & analysis in a 10-member team, to conduct a clinical study for evaluating the efficacy of BMI operated exoskeleton therapy in stroke rehabilitation.

- o Results from 10 chronic stroke participants indicate on avg. 9% improvement in arm function after 12 therapy sessions. At 2-months follow-up, 4 participants had retained motor improvements above minimal clinically relevant difference.
  - o Developed machine learning methods to use the Readiness Potential for detecting motor intents and for tracking motor recovery during BMI-exoskeleton therapy.

- Researcher, Robotics Engineering, Daegu Gyeongbuk Inst. of Sci & Tech., South Korea
  Sept. 2011 – Jul. 2012
  - o Integrated an optical tracking system with augmented reality, to navigate surgical instruments during image-guided endoscopic surgery with ~5mm tracking error.
  - o Carried forward code development of existing Windows API in C++, added GUI features, formalized procedures for testing, validation, and code documentation.

- Embedded Systems Engineer, Citizen Scales Pvt. Ltd., India
  Mar. – Jul. 2008
  - o Developed wireless communication for industrial weighing scales using low-power RF transceivers. A working prototype was developed and tested in 4 months.
  - o Helped expand company's product line and competitiveness with remote monitoring capability.

Journal Publications

- **N. Bhagat**, G. Francisco, J. Contreras-Vidal, "*A State-Space Control Approach for Tracking Isometric Grip Force during BMI enabled Neuromuscular Stimulation*". IEEE Transactions on Human-Machine Systems, 2023, 1–10. View Online

- S. Chandrasekaran, **N. Bhagat**, R. Ramdeo, S. Ebrahimi, P. Sharma, D. Griffin, A. Stein, S. Harkema, C. Bouton, "*Targeted transcutaneous spinal cord stimulation promotes persistent recovery of upper limb strength and tactile sensation in spinal cord injury: a pilot study*," Frontiers in Neuroscience, 2023, vol. 17 (July). View Online

- S. Chandrasekaran, **N. Bhagat**, R. Ramdeo, S. Ebrahimi, P. Sharma, D. Griffin, A. Stein, S. Harkema, C. Bouton, "*Case study: Persistent recovery of hand movement and tactile sensation in peripheral nerve injury using targeted transcutaneous spinal cord stimulation*," Frontiers in Neuroscience, 2023, vol. 17 (July). View Online

- **N. Bhagat**, N. Yozbatiran, J. Sullivan, R. Paranjape, C. Losey, Z. Hernandez, Z. Keser, R. Grossman, G. Francisco, M. O'Malley, J. Contreras-Vidal, "*Neural activity modulations and motor recovery following brain-exoskeleton interface mediated stroke rehabilitation*," NeuroImage: Clinical, 2020, 28; 102502. View Online

- C. Bouton, **N. Bhagat**, S. Chandrasekaran, J. Herrero, N. Markowitz, E. Espinal, J. Kim, R. Ramdeo, J. Xu, M. Glasser, S. Bickel, A. Mehta, "*Decoding Neural Activity in Sulcal and White Matter Areas of the Brain to Accurately Predict Individual Finger Movement and Tactile Stimuli of the Human Hand,*" Frontiers in Neuroscience, 2021, vol. 15 (August). View Online

- S. Chandrasekaran, S. Bickel, J. Herrero, J. Kim, N. Markowitz, E. Espinal, **N. Bhagat**, R. Ramdeo, J. Xu, M. Glasser, C. Bouton, A. Mehta, "*Evoking highly focal percepts in the fingertips through targeted stimulation of sulcal regions of the brain for sensory restoration,*" Brain Stimulation, 2021, vol. 14, pp. 1184–1196. View Online

- A. Paek, J. Brantley, A. Ravindran, K. Nathan, Y. He, D. Eguren, J. Cruz-Garza, S. Nakagome, D. Wickramasuriya, J. Chang, M. Rashed-Al-Mahfuz, R. Amin, **N. Bhagat**, J. Contreras-Vidal, "*A Roadmap Towards Standards for Neurally Controlled End Effectors,*" in IEEE Open Journal of Engg. Med. and Bio., 2021, vol. 2, pp. 84-90. View Online

- **N. Bhagat**, K. King, R. Ramdeo, A. Stein, C. Bouton, "*Determining grasp selection from arm trajectories via deep learning to enable functional hand movement in tetraplegia*", Bioelectron Med, 2020, 6; 17. View Online

- **N. Bhagat**, A. Venkatakrishnan, B. Abibullaev, E. Artz, N. Yozbatiran, A. Blank, J. French, C. Karmonik, R. Grossman, M. OMalley, G. Francisco, and J. Contreras-Vidal, "*Design and optimization of an EEG-based BMI to an upper-limb exoskeleton for stroke survivors,*" Frontiers in Neuroscience, 2016, vol. 10, no.122. View Online

- J. Contreras-Vidal, **N. Bhagat**, J. Brantley, J. Cruz-Garza, Y. He, Q. Manley, S. Nakagome, K. Nathan, S. Tan, F. Zhu, & J. Pons, "*Powered exoskeletons for bipedal locomotion after spinal cord injury,*" J Neural Eng., 2016, vol. 13, no. 3, p. 031001. View Online

- S. Liew, H. Agashe, **N. Bhagat**, A. Paek and T. Bulea, "*A clinical roadmap for brain-neural machine interfaces: trainees' perspectives on the 2013 international workshop,*" in IEEE Pulse, vol. 4, no. 5, pp. 44-48, Sept. 2013. View Online

Conference Publications

- **N. Bhagat** and M. Ruppa, "*Using Object Detection to Select Grasp Type & Control Functional Electrical Stimulation (FES) for Hand Rehabilitation,*" 10th Int'l Conf. on Signal Processing and Integrated Networks (SPIN), Noida, Delhi-NCR, India, 2023, pp.538-542. View Online

- J. Sullivan, **N. Bhagat**, N. Yozbatiran, R. Paranjape, C. Losey, R. Grossman, J. Contreras-Vidal, G. Francisco, M. O'Malley, "*Improving robotic stroke rehabilitation by incorporating neural intent detection: Preliminary results from a clinical trial*", 2017 IEEE International Conference on Rehabilitation Robotics (ICORR), London, 2017, pp. 122-127. View Online

- **N. Bhagat**, J. French, A. Venkatakrishnan, N. Yozbatiran, G. Francisco, M. O'Malley, and J. Contreras-Vidal, "*Detecting movement intent from scalp EEG in a novel upper limb robotic rehabilitation system for stroke,*" 36th Annual Int'l Conf. of IEEE EMBS, Chicago, IL, 2014, pp. 4127-4130. View Online

- R. Bobade, P. Gandhi, **N. Bhagat**, and C. Chen, "*Cancellation of physiological hand tremors using compliant robotic assist,*" ASME 2013 View Online

Abstracts (peer-reviewed)

- S. Chandrasekaran, **N. Bhagat**, R. Ramdeo, S. Ebrahimi, P. Sharma, A. Stein, D. Griffin, S. Harkema, C. Bouton, "*Targeted transcutaneous cervical spinal cord stimulation promotes upper limb recovery in spinal cord and peripheral nerve injury*," 5th Int'l Brain Stimulation Conf., Lisbon, Feb 2023, vo. 16, pg. 373.

- **N Bhagat**, S. Chandrasekaran, R. Ramdeo, S. Bickel, J. Herrero, A. Stein, A. Mehta, and C. Bouton, "*Transcutaneous spinal cord stimulation selectivity and optimization for hand restoration in tetraplegia*," Abstracts from the Fourth Bioelectronic Medicine Summit: Technology Targeting Molecular Mechanisms. Bioelectron Med 6, 25 (2020). View Online

- **N. Bhagat**, A. Vegesna, C. Li, L. Rieth, R. Ramdeo, C. Bouton, H. Rilo, and L. Miller, "*Electrically evoked vagus nerve recordings using transmural endoscopy in a swine model*," Abstracts from the Fourth Bioelectronic Medicine Summit: Technology Targeting Molecular Mechanisms. Bioelectron Med 6, 25 (2020). View Online

- **N. Bhagat**, M. Hogan, V. Desai, D. Sayenko, G. Britz, P. Horner, "*Transcranial Electrical and Magnetic Stimulation for Motor Assessment in a Swine Model for Intracerebral Hemorrhage*," Abstracts from the Second Annual CNS Neuroregeneration Strategies, Houston (2019).

- **N. Bhagat**, G. Francisco, and J. Contreras-Vidal, "Brain Machine Interface with Closed-Loop Neuromuscular Stimulation for Grasping in Stroke and Spinal Cord Injury Survivors" Abstracts from 2018 Gordon Research Conference on Neuroelectronic Interfaces, Galveston, TX (2018).

- **N. Bhagat**, R. Paranjape, C. Losey, N. Yozbatiran, J. Sullivan, R. Grossman, G. Francisco, M. O'Malley, J. Contreras-Vidal, "*Inter- and intra-session variability in brain machine interface control of an exoskeleton for upper extremity stroke rehabilitation*," Program No. 157.29. 2016 Neuroscience Meeting Planner. San Diego, CA: Soc. for Neurosci., 2016. View Online

- **N. Bhagat**, J. French, A. Venkatakrishnan, N. Yozbatiran, G. Francisco, M. O'Malley, J. Contreras-Vidal, "*Optimizing "go" time intervals to detect movement intent from single-trial movement related cortical potentials*" Abstracts from the 41st Neural Interfaces Conference. Dallas, TX, 2014. Neuromodulation: Technology at the Neural Interface, 17(5), e40–e127. View Online

Patents

- Methods for closed-loop neural-machine interface systems for the control of wearable exoskeletons and prosthetic devices. View Online
  - US patent US10092205B2, granted Oct. 2018.
  - Inventors – J. Contreras-Vidal, S. Prasad, A. Kilicarslan, **N. Bhagat**
  - **Individual contribution** – Developed the idea of subject-specific adaptive windows for segmenting EEG features, for training a machine learning algorithm, to classify motor intent (i.e., Go) vs. rest (No-go)

- o **Impact** – Significantly improved brain-machine interface performance over conventional fixed window approach in chronic stroke participants, as highlighted in *Bhagat et al, Frontiers in Neuroscience, 2016*
- Neuromuscular stimulation using multistage current driver circuit. View Online
  - o US patent US11052249B2, granted Jul. 2021
  - o Inventors – **N. Bhagat**, J. Contreras-Vidal
  - o **Summary** – A novel constant current source is developed by cascading conventional Howland current pump and current mirror circuits, to result in a low-cost, power efficient as well as high-voltage compliant neuromuscular stimulator.
- Device for generating, controlling, and monitoring movement using electrical stimulation
  - o Inventor – **N. Bhagat**
  - o Provisional patent (202221029416) filed in India on May 23rd, 2022.

Selected Presentations

- **Invited** speaker on "*Brain-Machine Interface & Functional Electrical Stimulation to Restore Movements following Paralysis*" organized by CNS Dept., IISc, Sept. 2023

- **Invited** speaker on "*Brain-Machine Interface & Neuromuscular Stimulation to Restore Arm & Hand Movements following Paralysis*" organized by EE Dept., IIT Bombay, Jan. 2022

- **Invited** speaker on "*NeuroRehabilitation after Stroke and Spinal Cord Injury*" organized by Amity School of Applied Sciences at Amity University Rajasthan, Jaipur, 2021

- **Invited** speaker on "*Intent Driven NeuroRehabilitation for Restoring Movement after Stroke and Spinal Cord Injury*" at UTHealth PM&R Grand Rounds and TIRR NeuroRecovery Research Center Seminar, Houston, 2020

- **Invited** oral presenter on "*Brain-machine interface with closed-loop FES*" at Gordon Research Conference on Neuroelectronic Interfaces, Galveston, 2018

- **Invited** speaker on "*Brain-machine interfaces*" at 8th Annual Yatsu Day Symposium, University of Texas Health Science Center, Houston, 2015

- Presented "*Brain-machine interface controlled robotic rehabilitation following stroke,*" at Annual Graduate Research Conference, University of Houston, 2013

Awards and Fellowships

- Awarded ₹10 lacs under **Amrit Grand Challenge JanCare** by BIRAC for developing a remote rehabilitation platform for stroke recovery

- Received DBT's **Ramalingaswami Re-entry Fellowship** in August 2022 with ₹50 lacs research funding and ₹73 lacs for salary & overheads

- Awarded ₹10 lacs under **Nidhi Prayas** program from DST for prototyping a post-stroke hand rehabilitation device using neuromuscular stimulation.

- Winner of Microchip Technology's **2020 Get Launched** Initiative for creating an open source neurostimulator (NeuroStimDuino) for researchers & hobbyists, available on Crowd Supply

- **Finalist** in Innovation Pitch Competition held at 2017 National Science Foundation IUCRC Meeting, Arlington. Selected among 4 finalists from 25 contestants.

- **Finalist** for Poster Presentation at 2017 International Symposium on Wearable & Rehabilitation Robotics, Houston

- Led a 2-member team in Coulter College 2016, a 6-months long entrepreneurship program, for commercializing medical devices.
  - We were among the 15 teams, selected from across US.
  - Received $25K fellowship and $2500 travel award from NIH.

- Won **3rd prize** for poster presentation at 2016 Medical World Americas Conference and Expo, Houston

- Recipient of 2012 Presidential Fellowship and Houston Endowment Fellowship for $3000 from University of Houston

- Completed **future faculty** program, a two-semester long program to enhance research and teaching skills via grant writing, discussions with distinguished faculty, peer evaluations, course and lecture planning, and mock teaching sessions.

Professional Affiliations, Academic and Community Service

- Appointed Member of Selection Committee on Brain-Computer Interface Standards (LITD 37), by the Bureau of Indian Standards (BIS) (July 2023 onwards)

- IEEE Member (since 2018), IEEE Young Professionals (2018 - 19), IEEE Student Member (2014), Society for Neuroscience (2013, 2016)

- Reviewer for IEEE Trans. Neural Sys. & Rehab. Engg., Frontiers in Neuroscience, Human Neuroscience, & Neurorobotics, Applied System Innovation MDPI, Technologies MDPI, IEEE Trans. Human Machine Sys., and J. Neuroengg. & Rehab., IEEE Transactions on Haptics, Brain-Computer Interfaces, Brain Communication

- Demonstrated BMI controlled exoskeleton therapy to a live audience at the Congressional Robotics Caucus, Washington DC, 2016. View details online

- Member (2009-11) of IIT Bombay's student satellite initiative "Pratham", launched in 2016. Designed telemetry & beacon circuits for satellite communication.

- Volunteered at Children's Museum, art exhibitions, and other outreach activities for demonstrating BMIs and lower limb exoskeletons.

- Volunteered for hurricane flood relief (2017), Houston SPCA (2014-15), Red Cross (2013), teaching English to Korean students (2011-12), and educating underprivileged children (2009-11)

Research Interests

- Bio-signal processing, applied machine learning, medical instrumentation.
- Brain-machine interfaces for movement restoration and motor recovery
- Peripheral motor and sensory nerves stimulation
- Application of feedback control principles to physiological systems
- Artificial Intelligence and Computer Vision for Remote Assessment of Patient Recovery

Technical Skills

- EEG/EMG/ENG acquisition, processing, time, and frequency domain analysis
- Mixed signals circuit design and simulations: LTSpice, PSpice
- Flexible and rigid printed circuit board layouts: Eagle, Altium
- Embedded systems design: ARM, PIC, and AVR µControllers
- Programming languages: C, C++, MATLAB, R, Python

References

- Jose L. Contreras-Vidal, PhD
  Hugh Roy and Lillie Cranz Cullen Distinguished Professor
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  Director, Laboratory for Noninvasive Brain-Machine Interface Systems
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- Nitish V. Thakor, PhD
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