

Biswarup Mukherjee, PhD

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Research Interests

Sensors and Instrumentation, Rehabilitation Engineering, Ultrasound imaging, Embedded systems, Haptics

Education

- 2010-2015** PhD in Electrical Engineering
Indian Institute of Technology Madras, Chennai, India.
Thesis: *Novel capacitive and magnetic sensing schemes for an ophthalmic anesthesia training system.*
- 2006-2010** B.Tech in Electronics and Instrumentation Engineering
West Bengal University of Technology, Kolkata, India.
Thesis: *A glove based haptic human computer interface for the visually impaired.*

Appointments

- Mar 2020 - present** Assistant Professor
Center for Biomedical Engineering
Indian Institute of Technology Delhi, India
- Aug 2018 - Jan 2020** Research Assistant Professor, Biomedical Imaging Laboratory
Center for Adaptive Systems of Brain-Body Interactions
George Mason University, USA
- Aug 2017 - July 2018** Postdoctoral Research Fellow, Biomedical Imaging Laboratory
George Mason University, USA
- Feb 2015 - July 2017** Postdoctoral Fellow, Simulation Group
Massachusetts General Hospital, USA
- Feb 2015 - July 2017** Research Fellow
Harvard Medical School, USA.

Research Projects

- 1. Ultrasound-based Control of Upper-Extremity Prostheses:** I am currently leading a multidisciplinary team in an effort to develop novel, non-invasive, ultrasound imaging based strategies to detect volitional motion intent in transradial amputees and thus enable dexterous control of upper-extremity prostheses. I am directly involved in: **(a)** the development and characterization of low-power, miniaturized ultrasound imaging systems, associated transducer arrays and instrumentation backend to allow imaging of forearm muscle compartments; **(b)** optimization of image processing algorithms to decode muscle activity from ultrasound image frames in resource constrained embedded processors; **(c)** integration of custom-developed ultrasound imaging system into prosthetic shells to enable closed-loop control of commercial prosthetic arms; **(d)** investigation of haptic feedback modalities to enhance sensorimotor perception and grasp performance of prostheses; **(e)** the design of human-subjects experiments, protocols and relevant outcome measures to validate these technologies in individuals with upper extremity amputation.

Funded through multiple grants from the Department of Defense, National Science Foundation and Virginia Commonwealth Research Commercialization Fund (Key personnel)

Media Coverage: American Institute of Ultrasound Medicine, ArmyTimes

2. **Multiaxial, Multi-Instrument Tracker for an Interventional Radiology Simulator** - Developed a tracking system with perceptual haptic feedback for multiple instruments such as microcatheters or guidewire and demonstrated its utility for training endovascular techniques to military and civilian users.
Funded by the Department of Defense.
3. **SimSuit** - The project involved the development of a suite of modular presence-providing add-ons for legacy mannequins and standardized patients to augment medical training realism at a low-cost. Developed a wearable body suit with IoT-enabled, low-cost, battery-powered modules to simulate breathing, palpable pulsation, eye-movements etc and demonstrated its efficacy in leading simulation centers in Boston-area hospitals.
Funded by the Department of Defense.
4. **Handheld Haptic Intravenous Catheterization Device** - Developed a portable device to provide realistic training with integrated feedback and teaching materials prior to starting IVs on pediatric patients. Designed novel instrumentation system with tissue simulant gel block with variable stiffness but uniform electrical resistivity to enable tracking of needle tip trajectory through skin, soft tissue and into the vessel lumen.
Funded by the Consortia for Improving Medicine with Innovation & Technology.
5. **Ocular and Facial Trauma Simulator** - For medical personnel from the point of injury to first hospitalization, there are needs for training systems to provide exposure to typical oculo-facial injuries, and the opportunity to learn situationally relevant treatment. The work involves the development of an enucleation module with accurate ocular anatomy and embedded sensors for task segmentation. A mid-face open fracture module is also being developed to train the surgical skills to realign bone fragments, apply fixation and repair the soft tissues.
Funded by the Department of Defense.
6. **Additive Manufacturing with Silicone Elastomers** - Developed a 3D printer capable of deposition modelling with high viscosity silicone elastomers to allow rapid prototyping of silicone parts. The technology allows condensation cure, two-part silicones to be 3D printed in a gel bath with extruders capable of mixing silicones of different hardness to achieve continuously variable intermediate hardness.
7. **Ophthalmic Anesthesia Simulator** - Developed an anatomically precise ophthalmic anesthesia training system with novel capacitive sensors integrated in the mannequin to detect the proximity and trajectory of the needle to simulated ocular structures. A magnetic sensing system detects rate of injection from the syringe to provide qualitative and quantitative feedback during training. Established construct and face validity in a large-scale, structured clinical trial.
Awarded best PhD Thesis Award at IIT Madras

Publications and Patents

Refereed Journal Publications

Accepted and Published

1. Dhawan A.*, Mukherjee B.*, Patwardhan S.*, Akhlaghi N., Diao G., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Proprioceptive sonomyographic control: A novel method of intuitive proportional control of multiple degrees of freedom for upper-extremity amputees*”, Nature Scientific Reports 2019, 9, pp. 9499. (IF: 4.525)
2. Akhlaghi N., Dhawan A., Khan A.A., Mukherjee B., Diao G., Truong C., Sikdar S., “*Sparsity analysis of a sonomyographic muscle-computer interface*”, IEEE Transactions on Biomedical Engineering (accepted) (IF: 4.491)
3. Mukherjee B., Venkatakrishnan J.V., George B., Sivaprakasam M., “*Evaluation of an ophthalmic anesthesia simulation system for regional block training.*”, Ophthalmology 2015, 122(12), pp. 2578-2580. (IF: 7.732)
Featured in issue editorial
4. Mukherjee B., George B., Sivaprakasam M., “*A multi-electrode electric field based sensing system for ophthalmic anesthesia training.*”, IEEE Transactions on Biomedical Circuits and Systems 2015, 9(3), pp. 431-440. (IF: 4.252)

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5. **Mukherjee B.**, Sivaprakasam M., “*An eye toward improving: a new training approach in ophthalmic anesthesia provides qualitative and quantitative feedback.*”, IEEE Pulse 2015, 6(4), pp. 20-25. (Invited, IF: 0.662)
6. **Mukherjee B.**, George B., Sivaprakasam M., “*An ophthalmic anesthesia training system using integrated capacitive and hall effect sensors.*”, IEEE Transactions on Instrumentation and Measurement 2014, 63(5), pp. 1153-1162.(IF: 3.067)

In preparation

1. **Mukherjee B.**, Dhawan A., Gammell P., Chitnis P., Sikdar S., “*A low-power, wearable ultrasound imaging system for sonomyographic applications*”, Journal of NeuroRehabilitation and Engineering (in preparation).
2. **Mukherjee B.**, Dhawan A., Patwardhan S., Akhlaghi N., Holley R, Dromerick A., Joiner W., Chitnis P., Gyorgy L., Kaliki R., Sikdar S., “*Sonomyography enables robust isolation of multiple degrees of freedom with minimal training in individuals with upper limb loss*”, Journal of NeuroRehabilitation and Engineering (in preparation).
3. Patwardhan S, **Mukherjee B.**, Azalmani M., Dhawan A., Joiner W.M., Sikdar S., “*Vibrotactile haptic feedback improves sonomyographic positional proportional control performance in individuals with upper-extremity limb loss*, IEEE Transactions on Haptics (in preparation).

Conference Proceedings

1. Patwardhan S., **Mukherjee B.**, Dhawan A., Alzalmani M., Noor A., Engdahl S., Joiner W.M., Sikdar S., “*Sonomyography combined with vibrotactile feedback enables precise target acquisition without visual feedback*”, 42nd Annual International Conferences of the IEEE Engineering in Medicine and Biology Society (EMBC) 2020, Montreal, Canada. (Submitted)
2. Patwardhan S., Dhawan A.*, **Mukherjee B.***, Alzalmani M., Joiner W.M., Sikdar S., “*Evaluation of the role of proprioception during proportional position control using sonomyography: applications in prosthetic control*”, IEEE International Conference on Rehabilitation Robotics (ICORR) 2019, pp. 830-836, Toronto, Canada.
3. Tarbox E., Akhlaghi N., Dhawan A., **Mukherjee B.**, Gammell P., Chitnis P., Sikdar S., “*Low-power ultrasound imaging systems using time delay spectrometry.*”, IEEE International Ultrasonics Symposium (IUS) 2017, pp. 1-4, Washington, DC.
4. **Mukherjee B.**, George B., Sivaprakasam M., “*A simple measurement scheme for multiple capacitors and its application to an ophthalmic anesthesia training system.*”, IEEE International Instrumentation and Measurement Technology Conference (I2MTC) 2015, pp. 458-463, Pisa, Italy.
5. **Mukherjee B.**, George B., Sivaprakasam M., “*An efficient capacitive sensing scheme for an ophthalmic regional anesthesia training system.*”, 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) 2013, pp. 894-897, Osaka, Japan.
6. **Mukherjee B.**, George B., Sivaprakasam M., “*A syringe injection rate detector employing a dual Hall-effect sensor configuration.*”, 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) 2013, pp. 4734-4737, Osaka, Japan.
7. **Mukherjee B.**, George B., Sivaprakasam M., “*An intelligent ophthalmic regional anesthesia training system based on capacitive sensing.*”, IEEE International Instrumentation and Measurement Technology Conference (I2MTC) 2013, pp. 889-893, Minneapolis, USA.
8. **Mukherjee B.**, George B., Sivaprakasam M., “*A hall effect sensor based syringe injection rate detector.*”, 6th IEEE International Conference on Sensing Technology 2012, pp. 450-453, Kolkata, India.
9. **Mukherjee B.**, George B., Sivaprakasam M., Kumar V.J., Venkatakrishnan J.V., “*A capacitive array sensing based training system for ophthalmic anesthesia.*”, 5th IEEE International Conference on Sensing Technology 2011, pp. 623-627, Palmerston North, New Zealand.

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Posters, Oral Presentations and Abstracts

1. Engdahl,S., **Mukherjee B.**, Dhawan A., Patwardhan S., Joiner W., Sikdar S., “*Using sonomyography for proportional positional control in individuals with upper-limb loss*”, 46th Annual Meeting & Scientific Symposium of the American Academy of Orthotists and Prosthetists, Chicago, USA, March 2020. (Accepted for oral presentation)
2. **Mukherjee B.**, Dhawan A., Patwardhan S., Joiner W., Sikdar S., “*Proportional positional control of multiple degrees-of-freedom for individuals with upper extremity limb loss using sonomyography*”, Military Health Systems Research Symposium, Kissimmee, USA, Aug 2019. (Accepted for oral presentation)
3. **Mukherjee B.**, Dhawan A., Patwardhan S., Joiner W., Sikdar S., “*Proportional positional control of multiple degrees-of-freedom for individuals with upper extremity limb loss using sonomyography*”, Military Health Systems Research Symposium, Kissimmee, USA, Aug 2019. (Accepted for oral presentation)
4. **Mukherjee B.**, Dhawan A., Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Proprioceptive sonomyographic control: Towards natural and intuitive Control of multi-articulated upper extremity prosthesis*”, Military Health Systems Research Symposium, Kissimmee, USA, Aug 2019. (Accepted for poster presentation)
5. Patwardhan S., **Mukherjee B.**, Dhawan A., Akhlaghi N., Joiner W., Sikdar S., “*Safety and acoustic output characterization of a time delay spectrometry based ultrasound imaging system*”, International Symposium on Ultrasonic Imaging and Tissue Characterization, Washington D.C, USA, May 2019. (Oral presentation)
6. **Mukherjee B.**, Dhawan A., Tarbox E., Akhlaghi N., Gammell P., Chitnis P., Sikdar S., “*Proprioceptive sonomyographic control: A novel ultrasound-based method for prosthetic control for upper-extremity amputees*”, International Symposium on Ultrasonic Imaging and Tissue Characterization, Washington D.C, USA, May 2019. (Oral presentation)
7. Joiner W., Dhawan A., **Mukherjee B.**, Patwardhan S., Akhlaghi N., Levay G., Harris-Love M., Sikdar S., “*Ultrasound based muscle activity sensing for intuitive proportional control in upper extremity amputees*”, Neural Control of Movement 2019, Toyoma, Japan. (Oral presentation)
8. **Mukherjee B.**, Dhawan A., Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Ultrasound based muscle activity sensing for intuitive proportional control in upper extremity amputees*”, American Congress of Rehabilitation Medicine, Dallas, USA, Sep 2018.(Poster presentation)
9. **Mukherjee B.**, Dhawan A., Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Ultrasound-based muscle activity sensing for intuitive visual feedback and training of upper-extremity amputees*”, Military Health Systems Research Symposium, Kissimmee, USA, Aug 2018. (Poster presentation)
10. Dhawan A., **Mukherjee B.**, Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Ultrasound sensing-based intuitive proportional control: an evaluation study with upper-extremity amputees*”, 12th International Society for Physical and Rehabilitation Medicine World Congress, Jul 2018. (Poster presentation)
11. **Mukherjee B.**, Dhawan A., Tarbox E., Akhlaghi N., Gammell P., Chitnis P., Sikdar S., “*Comparison of time delay spectrometry and pulse-echo ultrasound imaging systems*”, International Symposium on Ultrasonic Imaging and Tissue Characterization, Washington D.C, USA, May 2018. (Oral presentation)
12. Dhawan A., **Mukherjee B.**, Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Ultrasound sensing-based intuitive proportional control: Evaluation study with upper-extremity amputees*”, International Symposium on Ultrasonic Imaging and Tissue Characterization, Washington D.C, USA, May 2018. (Poster presentation)
13. **Mukherjee B.**, Dhawan A., Patwardhan S., Majdi J., Holley R., Joiner W., Harris-Love M., Sikdar S., “*Intuitive proportional control with multiple degrees of freedom in upper extremity amputees using novel ultrasonic sensing of muscle activity*”, Extremity War Injuries Symposium XIII, Washington D.C, USA, Jan 2018. (Poster presentation)
14. Ottensmeyer M.P., **Mukherjee B.**, De Novi G.,”*REBOA training simulator with catheter tracking and haptic feedback*”, Military Health Systems Research Symposium 2017, Kissimmee, USA, May 2017. (Poster presentation)

15. **Mukherjee B.**, Mangiamele M., Loan G.J., De Novi G., Ottensmeyer M.P., “*Modular enhancements for low-cost and legacy mannequins: progress update*”, Military Health Systems Research Symposium 2016, Kissimmee, USA, May 2016. (Poster presentation)
16. **Mukherjee B.**, Mangiamele M., Loan G.J., De Novi G., Ottensmeyer M.P., “*Modular enhancements for legacy and low cost medical training mannequins*”, Military Health Systems Research Symposium 2015, Ft. Lauderdale, USA, May 2015. (Poster presentation)
17. **Mukherjee B.**, Joseph J., George B., Sivaprakasam M., Venkatakrishnan J.V., “*OASiS : A novel simulation platform for regional orbital block training*”, 3rd World Congress on Ophthalmic Anesthesia, Ankara, Turkey, May 2012. (Oral presentation)

Patents

1. Ottensmeyer M.P., Tessier P., **Mukherjee B.**, Gordon J., “*System and method for a wearable medical simulator*”, PCT/US16/35307. May 1st 2016, Boston, USA.
2. **Mukherjee B.**; George B.; Sivaprakasam M., “*System and method for ophthalmic anesthesia training*”, 2023 /CHE/2013. May 6th 2013, Chennai, India.
3. **Mukherjee B.**; George B.; Sivaprakasam M., “*Measuring the rate of injection in a syringe*”, 1993/CHE/2013. May 3rd 2013, Chennai, India.

Awards

Feb 2020	Distinguished Alumnus Award, Gurunanak Institute of Technology, Kolkata, India
May 2017	2016 Innovation Discovery Award for contribution to innovation at Partners Healthcare, Boston, USA
Nov 2015	Best Poster Award at Annual Meeting of British Ophthalmic Anesthesia Society, London, UK
Jul 2015	Dr. M Mukunda Rao Endowment Prize for Best PhD Thesis in Interdisciplinary Research, Chennai, India
May 2013	Travel Award for IEEE Instrumentation and Measurement Technology Conference 2013, Minneapolis, USA
Aug 2012	Best Paper Award at 3rd World Congress of Ophthalmic Anesthesia, Ankara, Turkey

Teaching and Mentoring Experience

Aug 2017 - Present	Mentoring multiple graduate and undergraduate students and interns at George Mason University.
Oct 2016 - June 2017	Mentored a graduate student intern from University of Bologna at the Simulation group.
Jul 2015 - Dec 2015	Mentored a graduate student intern from University of Rome-Sapienza at the Simulation group.
June 2016 - Aug 2016	Mentored 3 high school students at the Simulation group
June 2013 - June 2014	Teaching assistant for two graduate level courses at Indian Institute of Technology Madras “Analog and Digital Circuits” and “Biomedical Electronic Systems”.
June 2014- Dec 2014	Mentored an undergraduate student at Indian Institute of Technology Madras.
Jan 2013 - May 2013	Teaching Assistant for an undergraduate level course at Indian Institute of Technology Madras “Principles of Measurement”.

Invited Talks

1. *SimSuit: A modular, wearable and IoT-based medical simulation platform* at the Biorobotics Lab, Harvard University, USA, May 2017.
2. *Simulation in ophthalmic anesthesia training.* at the Advanced Eye Center, Post Graduate Institute of Medical Education & Research, Chandigarh, India, March 2013.
3. *Learning through mannequins: advances in ophthalmology training* at the Annual Meet of the Ophthalmology Association of Assam, Dibrugarh, India Nov 2012.

Synergistic Activities

1. Technical consultant, Nestle Gladerma Skin Health, Washington, D.C, 2019 - present.
2. Associate Editor for IEEE International Conference on Rehabilitation Robotics 2019, Toronto, Canada.
3. Reviewer for IEEE Sensors Journal, IEEE Transactions on Instrumentation and Measurement, IEEE Transactions on Industrial Electronics, IEEE Transactions on Biomedical Circuits and Systems, Ultrasound in Medicine and Biology.
4. Member of expert panel on "*Technical specifications for mannequin based simulators*" for Ministry of Health and Family Welfare, Government of India.