OMB No. 0925-0001 and 0925-0002 (Rev. 03/2020 Approved Through 02-28-2023)

BIOGRAPHICAL SKETCH

**Provide the following information for the Senior/key personnel and other significant contributors.**

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NAME: Rahman, Mohammad H.

eRA COMMONS USER NAME (credential, e.g., agency login): MHRAHMAN

POSITION TITLE: Director, Bio-Robotics Lab; Associate Professor, Mechanical Engineering Department, University of Wisconsin Milwaukee, Milwaukee, WI, US

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

| INSTITUTION AND LOCATION | DEGREE(if applicable) | Completion DateMM/YYYY | FIELD OF STUDY |
| --- | --- | --- | --- |
| Khulna University of Engineering & Technology, Bangladesh | B. S | 07/2001 | Mechanical Engineering |
| Saga University, Saga, Japan | M. E | 09/2005 | Mechanical Engineering (bio-robotics) |
| École de technologie supérieure, Montreal, CanadaMcGill University, Montreal, Canada | Ph. DPostdoctoral | 09/20122014 | Electrical Engineering (bio-robotics)Rehabilitation Robotics |
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# A. Personal Statement

As Director of the BioRobotics Lab at the University of Wisconsin-Milwaukee, I bring the resources and expertise of an interdisciplinary R&D team. For more than 15 years, I have been researching bio-mechatronics/bio-robotics with emphasis on the design, development, and control of wearable robots (to rehabilitate and assist elderly and physically disabled individuals who have lost their upper-limb function or motion due to spinal cord injury, Cerebral Vascular Accident (CVA), amyotrophic lateral sclerosis (ALS), trauma, and occupational injuries). I have a highly interdisciplinary background with degrees and experiences in mechanical engineering (design, development, and manufacturing), electrical and electronics engineering (instrumentation and programming), robotics and control disciplines (modeling and configuration, simulation, and controller design), and rehabilitation/biomedical engineering (biomechanical modeling, and analyses that include physiological signal (EMG, EEG) detection, and processing). At UWM, my research teams have developed several assistive robots and rehab robots for personalized rehabilitation and home health care. I have recently received a NIDILRR: DRRP grant (Award # 90DPGE0018-01-00) , where I am collaborating with the proposed NIH-R01 Project’s other PIs/Co-PIs (Dr. Ahamed, Dr. Wang, and Dr. McGonigle) to develop a wheelchair-mounted multifunctional assistive robot arm to assist individuals in activities of daily living. My research team has also developed IIOT based novel framework with augmented and mixed reality systems for remote collaboration and telerehabilitation with an assistive robot. Currently, I supervise seven Ph.D. students, five Master’s students, and five undergraduate students. I have published more than 100 technical papers in referred journals and international conferences in my field of interest. I have strong expertise in rehabilitation and assistive robotics, augmented/mixed reality, intelligent system and control, nonlinear control, control using biological signals, and artificial intelligence. I will bring all this expertise to this proposed NIH project to develop the proposed telerehabilitation system through the synergistic integration of mobile Health (mHealth), Industrial Internet of Things (IIOT), mixed reality platform (HoloLens-2), and assistive robots (SREx, and ITbot developed in my Lab). Some relevant research articles are listed in the following:

1. **Rahman, M. H.,** Rahman, M. J., Cristobal, O. L., Saad, M., Kenne, J. P., & Archambault, P. S. (2014). Development of a Whole Arm Wearable Robotic Exoskeleton for Rehabilitation and to Assist Upper Limb Movements. *Robotica,* 2014, 1-21, online: DOI: http://dx.doi.org/10.1017/S0263574714000034
2. **I**slam MR,Rahmani M, **Rahman M. H.** (2020). A Novel Exoskeleton with Fractional Sliding Mode Control for Upper Limb Rehabilitation. Robotica. 2020; 38(11): 2099-2120
3. Brahimi, B. Saad, M., Rahman**,** **M.H.,** and Ochoa Luna, C. (2017). Cartesian Trajectory Tracking of a 7-DOF Exoskeleton Robot Based on Human Inverse Kinematics. IEEE Transactions on Systems, Man, and Cybernetics: Systems, PP (99), pp. 1-12. DOI: 10.1109/TSMC.2017.2695003
4. **Rahman**, **M. H.,** Cristobal, O. L., Saad, M., & Archambault, P. (2015). EMG Based Control of a Robotic Exoskeleton for Shoulder and Elbow Motion Assist, *Journal of Automation and Control Engineering, 3 (4), 270-276. 2015*.
5. Janarthanan V, Assad-Uz-Zaman M, **Rahman M.H.,** McGonigle E, Wang I. (2020) Design and development of a sensored glove for home-based rehabilitation. J Hand Ther. 2020 Apr-Jun;33(2):209-219. doi: 10.1016/j.jht.2020.03.023. Epub 2020 May 23. PMID: 32451172**.**

# B. Positions and Honors

## Positions and Employment

2020-Present Associate Professor, Biomedical Engineering, University of Wisconsin-Milwaukee, USA

2020-Present Associate Professor, Mechanical Engineering, University of Wisconsin-Milwaukee, USA

2016-2020 Assistant Professor, Biomedical Engineering, University of Wisconsin-Milwaukee, USA

2015-2020 Assistant Professor, Mechanical Engineering, University of Wisconsin-Milwaukee, USA

2014-2014 Research Assistant, Robotics Design Inc, Montreal, Canada

2012-2014 Postdoctoral Research Fellow, Rehabilitation Robotics Lab, McGill University, Canada

2012-2014 Visiting Postdoc Fellow, Biorobotics Lab, École de Technologie Supérieure, Canada

2007-2012 Research Assistant, Biorobotics Research Lab, École de Technologie Supérieure, Canada

2005-2012† Assistant Professor, Khulna University of Engineering & Technology, Bangladesh († On deputation for Ph.D. from Jan 2007 to March 2012)

* 1. Research Assistant, Robotics & Advanced System Control Lab, Saga University, Japan

## Other Experience and Professional Memberships

2018-Present Associate Editor, Frontiers in Robotics and AI: Biomedical Robotics

2019-Present Guest Editor, Special Issue- Wearable Robotics, Micromachines, MDPI

2016-Present Member, Rehabilitation Engineering and Assistive Technology Society of North America
 (RESNA)

2017-Present Member, Biomedical Engineering Society (BMES)

2016-Present Member, American Society of Mechanical Engineers (ASME)

2019- Present Senior Member, Institute of Electrical and Electronics Engineers (IEEE)

2012-Present Member, Professional Engineers Ontario (PEO)

2001-Present Member, Institution of Engineers, Bangladesh

2019-2015 Member, CRIR - Centre for Interdisciplinary Research in Rehabilitation, Canada

2004-2005 Member, Japan Society of Mech. Engineers, (JSME), 2003-2005

## Honors

2018 Best Paper Awards, Int. Conf. of Control, Dynamic Systems, and Robotics, June 7-8, 2018

2012-2014 Postdoctoral research scholarships-B3, Fonds de recherche du Québec Nature et technologies, 1st position in Group-Techniques, Measurements and Systems in 2012 competition

2008 Doctoral research scholarships-V1, Ministère de l'Éducation, du Loisirs et du Sport du Québec (1st position).

2003-2005 Japanese Government’s Monobukagakusho Scholarship (2 Years study in M. Engg.)

2001 Award received from Institution of Engineers Bangladesh (IEB)

# C. Contribution to Science

1. **Wearable Robot Design**

**Fundamentally, my research focuses on the design, development, and control of exoskeleton robots** to rehabilitate and assist individuals with impaired upper-limb function. I designed and developed innovative wearable robots for upper-extremity rehabilitation. Some of the relevant publications are as follows:

1. **I**slam MR,Rahmani M, **Rahman MH.** A Novel Exoskeleton with Fractional Sliding Mode Control for Upper Limb Rehabilitation. Robotica. 2020; 38(11): 2099-2120
2. **Rahman, M. H.,** Rahman, M. J., Cristobal, O. L., Saad, M., Kenne, J. P., & Archambault, P. S. (2014). Development of a Whole Arm Wearable Robotic Exoskeleton for Rehabilitation and to Assist Upper Limb Movements. Robotica, 2014, 1-21, online: DOI: http://dx.doi.org/10.1017/S0263574714000034.
3. **Rahman, M. H.,** Ouimet, T. K., Saad, M., Kenne, J. P., & Archambault, P. S. (2012). Development of a 4DoFs Exoskeleton Robot for Passive Arm Movement Assistance. Int. J. Mechatronics and Automation, 2(1), 34-50.
4. Kiguchi, K., **Rahman, M. H.,** Sasaki, M., & Teramoto, K. (2008). Development of a 3DOF mobile exoskeleton robot for human upper-limb motion assists. Robotics and Autonomous Systems, 56(8), 678-691.
5. **Rehabilitation Engineering**

**For over a decade, I have performed research in rehabilitation robotics to develop rehabilitation robots and robotic rehabilitation protocol to provide robot-aided rehabilitation therapy to the elderly and/or physically disabled individuals with impaired upper limb functions resulting from strokes, traumatic brain injuries (TBI), sports injuries, cerebral palsy, occupational injuries, and spinal cord injuries (SCI). S**ome of the relevant publications are as follows:

1. **Rahman, M. H.,** M. Saad, J. P. Kenne, & P.S. Archambault. (2011). Robot assisted rehabilitation for elbow and forearm movements. Int. J. Biomechatronics and Biomedical Robotics, 1(4), 206-218.
2. B. Brahmi, M. Saad, C. Ochoa Luna, **M. H. Rahman**, P. Archambault. Passive and Active Rehabilitation of Human Upper-Limb Exoskeleton Robot with Dynamic Uncertainties. Robotica (in press).
3. Cristóbal O-L., **Rahman, M. H.,** Saad, M., Archambault, P. S. & Zhu, W-H. (2015). Admittance-Based Upper Limb Robotic Active and Active-Assistive Rehabilitation, Int J. of Advanced Robotic Systems, 12(114), 1-14.
4. **Rahman, M. H.,** Cristobal, O. L., Rahman, M. J., Saad, M., & Archambault, P. S. (2014). Force-position control of a robotic exoskeleton to provide upper extremity movement assistance. Int. J. Modelling Identification and Control, 21(4), pp.390-400.
5. **Nonlinear Control and Adaptive Control Engineering**

I developed novel nonlinear and adaptive control techniques to maneuver a therapeutic robot to deal with a wide range of patients with different degrees of upper extremity impairments. Some of the relevant publications are as follows:

1. B. Brahim, M. Saad, **M. H. Rahman,** and C. Ochoa Luna (2017). Cartesian Trajectory Tracking of a 7-DOF Exoskeleton Robot Based on Human Inverse Kinematics. IEEE Transactions on Systems, Man, and Cybernetics: Systems, PP(99): 1-12. DOI: 10.1109/TSMC.2017.2695003.
2. B. Brahim, **M. H. Rahman,** M. Saad, and C. Ochoa Luna (2016). Iterative Estimator-Based Nonlinear Backstepping Control of a Robotic Exoskeleton. International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, World Academy of Science, Engineering and Technology, 10 (4), pp. 1279-1285
3. Cristóbal O-L., **Rahman, M. H.,** Saad, M., Archambault, P. S. & Zhu, W-H. (2014). Virtual Decomposition Control of an Exoskeleton Robot Arm. Robotica. October 2014, 1-23, DOI: 10.1017/S026357471400246X
4. **Rahman, M. H.,** Saad, M., Kenne, J. P., & Archambault, P. S. (2013). Control of an Exoskeleton Robot Arm with Sliding Mode Exponential Reaching Law. International Journal of Control, Automation and Systems, 11(1), 92-104.
5. **Biological Signal Analysis and Its Application in Robotics**

Developed an innovative control strategy using human skin-surface electromyogram (EMG) signals to maneuver an exoskeleton type wearable robot for assisting human upper-limb motion. Some of the relevant publications are as follows:

1. **Rahman**, **M. H.,** Cristobal, O. L., Saad, M., & Archambault, P. (2015). EMG Based Control of a Robotic Exoskeleton for Shoulder and Elbow Motion Assist, Journal of Automation and Control Engineering, 3 (4), 270-276. 2015.
2. **Rahman, M. H.,** Cristobal, O. L., Saad, M., & Archambault, P. (2014). Motion Control of an Exoskeleton Robot using EMG Signals, International Conference on Advances in Robotics, Mechatronics and Circuits, Greece, pp. 27-33.
3. Spiewak, C. S., Rasedul, M.R., **Rahman, M. H.,** Saad, M. (2017). Myo Signal Based Control of a Robotic Assistive Device for Hand Rehabilitation, IEEE 37th Annual Great Lakes Biomedical Conference (GLBC), Pewaukee, WI, USA, April 6-7, 2017.
4. Kiguchi, K., **Rahman, M. H.,** & Sasaki, M. (2006). Neuro-fuzzy based motion control of a robotic exoskeleton: considering end-effector force vectors. Proceedings of the 2006 IEEE International Conference on Robotics and Automation, pp. 3146-3151, Orlando, FL, USA.
5. **Tele Rehabilitation and Supervised Rehabilitation**

**I developed a novel control approach to tele-operate a therapeutic robot to provide telerehabilitation. I also developed a novel human-robot interaction platform where a robot can be used to demonstrate/instruct rehabilitation exercises to the group of individuals, and/or supervise a rehabilitation session and provide real-time feedback to the patients about their progress in the rehabilitation session.** Some of the relevant publications are as follows:

1. **Rahman, M. H.,** Ouimet, T. K., Saad, M., Kenne, J. P., & Archambault, P. S. (2011). Tele-operation of a Robotic Exoskeleton for Rehabilitation and Passive Arm Movement Assistance, 2011 IEEE International Conference on Robotics and Biomimetics, pp. 443-448, Phuket, Thailand.
2. Zaman, M.A.U., Islam, M. R., **Rahman, M. H.,** Schultz, K., McGonigle, E., & Wang, I. (2020). Robot sensor system for supervised rehabilitation with real-time feedback. Multimedia Tools and Applications, 79(35), 26643-26660.
3. Assad-Uz-Zaman, M., Islam, M.R, **Rahman, M.H.**, Wang, Y-C., McGonigle, E. (2020). Kinect controlled NAO Robot for Telerehabilitation, Journal of Intelligent Systems, 30(1), 224-239. doi: https://doi.org/10.1515/jisys-2019-0126
4. Assad-Uz-Zaman, M., Islam, M.R., and **Rahman, M.H.** (2018). Upper-Extremity Rehabilitation with NAO Robot, 5th International Conference of Control, Dynamic Systems, and Robotics (CDSR'18), Niagara Falls, Canada, June 7 - 9, 2018. (Received Best Paper Award)

# D. Additional Information: Research Support and/or Scholastic Performance

**Ongoing Research Support**

**M.H Rahman (PI)**, I Wang (Co-PI), S. Ahmed (Co-PI), and K Schultz (Co-PI), DHHS, NIDILRR. Multifunctional Robotic Assistive Arm (mR2A) for Activities of Daily Living Assistance, $1,491,780.00; 09/01/2020 – 08/31/2023.

**M.H Rahman (PI)**, UWM Discovery Innovation Grant. Control of a Wearable Upper Extremity Exoskeleton Robot for Rehabilitation, $109, 652.00; July 2020 – June 2022.

**M.H. Rahman (PI)**, NSF, Innovation Corps - National Innovation Network Teams Program, I-Corps: Wheelchair Mounted Robotic Assistive Arm (WMR2A), $50,000.00, NSF Award #1848912, UWM Award ID: MIL114647, 09/25/18 – 08/31/2021.

**M.H. Rahman (PI)**, Asif Swapnil, Assad-Uz-Zaman, Ivan Ruilk, M-WREC Eaton Tech Challenge, Flexible PCB Based Modular Inductive Proximity Sensor, $10,000.00, 02/21/2022.

R. Fareh (PI), **M.H. Rahman (External Co-I)**, S. Khadraoui (Co-I), M. Bettayeb (Co-I), T. Rabie (Co-I), Source of Support: University of Sharjah, UAE, Development of an Intelligent Robot System to Instruct, Demonstrate, and Supervise Upper-Extremity Rehabilitation Session, AED $80,000\* (~21,780.00USD) 10/01/2018–09/31/2021.

**Completed Research Support**

**M.H. Rahman (PI)**, NASA-Wisconsin Space Grant Consortium, Research Infrastructure Program, Adaptive Coordinated Control of Multiple Mobile Manipulator Robots: An Analog of Multi-Robot Planetary Exploration, $10,000.00, NASA Training Grant #NNX15AJ12H, Award Reference # RIP19\_5.0, UWM Award ID: MIL115364, 03/01/2019 - 11/30/2020.

**Mohammad Rahman (PI)**, Customer Discovery: Kinetix: Assistive Robot for Wheelchair Users, NSF: I-Corps, $2,400 (sub-awards), 10/06/17 –03/31/2019.

Mohammad Rahman (PI), Customer Discovery: Powered Hand Rehab Glove, NSF: I-Corps, $2,400 (sub-awards), 02/14/18 –02/13/2019,

**M.H. Rahman (PI)**, NSF, I-Corps: Enhancing Regional Technology Commercialization, Smart Shoulder Rehabilitation Device (SS-RED), $2000.00 (sub-awards), NSF Award# 1829202, UWM Award ID: MIL114062 (Project# AAH5514), 10/28/19–03/31/2021.

**M.H. Rahman (PI)**, UWM Research Foundation- Catalyst Grant (Supported by Lynde and Harry Bradley Foundation), ‘Light Weight, Powered Hand Rehab Glove’, UWM Award ID: MIL114314, $45,000.00, 08/30/2018- 02/28/2021.

**M.H. Rahman (PI)**, NASA-Wisconsin Space Grant Consortium, Research Infrastructure Program, Coordination Control, and Obstacle Avoidance for a Team of Mobile Robots in Dynamic, $10,000.00, NASA Training Grant #NNX15AJ12H, Award Reference # RIP19\_5.0, UWM Award ID: MIL115364, 06/01/2020 - 03/31/2021.

**M.H. Rahman (PI)**, NASA-Wisconsin Space Grant Consortium, Higher Education Incentives Grant, Introducing Coordination Control of Mobile Robots Course to UWM-ME Program, $10,000.00, NASA Training Grant #NNX15AJ12H, Award Reference # HEI20\_2.0, 03/01/2020 - 03/31/2021.