

Midhun Parakkal Unni

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Education

University of Exeter

Ph.D. Mathematics

Exeter, UK

2017-Ongoing

- 2 Peer-reviewed journal publications
- International Excellence Scholarship, University of Exeter

Indian Institute of Technology Madras

Master of Technology, Clinical Engineering

Chennai, India

2008-2011

- Half Time Research Assistantship, Department of Biotechnology, India
- Scholarship and a travel grant to attend Summer School on Cognitive and Computational Neuroscience, CSHL-Asia by Department of Bio-Technology, India
- Second prize for best innovative Bio-mimicry design contest held during Tech-fest Shastra-2010, Indian Institute of Technology Madras, India

Government Engineering college, Kerala University

Bachelor of Technology, Mechanical Engineering

Kerala, India

2004-2008

Technical Skills

Mathematical modelling: Dynamical systems theory, numerical methods, differential equations, physiological systems modelling, and hybrid-dynamical systems.

Machine learning and optimization: Neural networks, genetic algorithms and other heuristic optimization techniques, Bayesian learning and Inference, random forest, and naïve bayes

Signal Processing: Time-frequency analysis and compressive sensing.

Software Skills

Languages: Python, MATLAB, Mathematica

Packages: Numpy, Scipy, matplotlib, scikit-learn, Keras, L1-Magic (MATLAB), Optimization Toolbox (MATLAB)

Design: SolidWorks

Standards Used: IEC 60812, 62366, ISO 13485, 14971

Other Skills

Leadership and Management:

- Management of a multi-disciplinary project in collaboration with designers, engineers, clinicians and mathematicians concerning technical aspects of the project - HCL Technologies
- Presented the work in international conferences; engaged with audiences from various disciplines. - TCS Research and Innovation
- Initiated Bio-Engineering Group at HCL Technologies, a platform where engineers from various domains can discuss, contribute & innovate solutions to medical problems.
- Assisted senior management in the preparation of project proposal by defining problem statement, creating an accurate description of the deliverables, identifying the resources, project timeline estimation, risk identification and preparation of mitigation plans and determining the business model for the project.

Independence and Creative Thinking:

- Full responsibility leading research projects; Identifies new areas of research; Designed the projects.

- Developed new approaches to combine mathematical models with machine learning techniques to generate valuable data insights.

Professional Experience

University of Exeter - Mathematical Modelling and Data Analysis for Freezing of Gait in Parkinson's Disease.....

Mathematical modelling

2017-Ongoing

- Developed a hybrid inverted-pendulum mathematical model and simulated neurally controlled walking dynamics in Parkinson's Disease. Captured rich behaviours such as chaos and periodic orbits. Authored a peer-reviewed journal article that points to management solutions for patients with movement difficulties.
- Effectively integrated the inverted pendulum system with a feedback-controlled central pattern generator. Demonstrated this hybrid dynamical model's ability to understand the effect of augmented feedback in alleviating freezing of gait, potentially be used in conjunction with wearable devices. Currently, authoring a journal article to be submitted.
- Developed a phase-reset-curve based model to study freezing of gait. A highly modular approach has been implemented to test other neural inputs and variations in neurophysiology. Leveraged the functional programming strengths of Mathematica in developing the system. This work is currently in preparation to be submitted as a journal article.

Machine Learning and Data Analysis

2017-Ongoing

- Developed a pre-processing technique to be used in a time series forecasting/predictive modelling scenario specific to the stepping force data.
- Converted the forecasting problem into a classification problem by appropriately segmenting the data.
- Built a pipeline and systematically evaluated and implemented different machine learning approaches (Neural Networks, Naïve Bayes, Random Forest) to predict freezing of gait in Parkinson's disease. The project was implemented using python packages such as scikit-learn and Keras.
- Used statistical approaches to understand the significance of the different conclusions made using the machine learning algorithms. Part of the machine learning work has been published as a journal article.

Researcher, TCS Research & Innovation, India.....

Mathematical Modelling and Machine Learning

2014-2016

- Developed an innovative technique to estimate stress from photoplethysmograph signal using a mathematical model. Neural network-based learning and numerical simulations were used to extract parameters from the model. Validated the conclusions derived from the algorithm using healthy participants' data. Authored an IEEE conference proceedings paper to communicate the results and generated a US patent grant for this invention
- Developed an early Screening technique for Motor Disorders using a neuromuscular model of the human arm using rigid body mechanics. Using Kinect data, the model's cost functionals were estimated using inverse optimal control and optimization methods in Python. Authored a peer-reviewed journal article and generated a patent filing for this work
- Developed a non-invasive blood pressure (BP) estimation algorithm using a constitutive model of the radial artery and machine learning. Employed genetic algorithms, Neural networks and maximum likelihood estimation techniques for estimating the blood pressure from the displacement signals measured using a piezoelectric sensor from the wrist and for optimizing model parameters. A European and Chinese patent has been granted for this project.

Signal Processing

2015-2016

- Reduced the memory requirement of a numerical method in solving differential equations using compressive sensing. Tested the algorithm on chaotic differential equations and partial differential equations. The algorithm has the potential to be used in embedded devices with memory constraints. This work resulted in a peer reviewed IEEE conference proceedings publication.
- Developed a time-frequency analysis based algorithm using Photoplethysmograph data to understand the effect of stress on heart rate variability. The work was presented as a poster in IEEE EMBC conference.

Lead Engineer, HCL Technologies, India – Engineering and R&D Services.....

Medical Devices - Risk Management

2013-2014

- Regulatory/risk management: Authored several risk management documents using the appropriate medical device standards
- Reverse Engineered Insulin pump algorithm and internal mechanisms. Conducted black-box tests to determine the algorithm used in the device and determined the internal mechanisms and working of the device, the clinical advantages and disadvantages of the algorithms and mechanisms used.

Mathematical Modelling for Device feasibility

2012-2013

- Numerically simulated a multi-scale model of arterial structure dynamics using MATLAB.
- Demonstrated the feasibility of an electromagnetic device to alleviate the symptoms of erectile dysfunction.
- Demonstrated the feasibility of a blue light device in alleviating erectile dysfunction using mathematical models.
- Demonstrated the feasibility of the device considering biocompatibility and manufacturing constraints.
- Developed CAD model of the device concept in SolidWorks

Medical Devices - Idea generation, Concept design

2011-2013

- Devices for erectile dysfunction & urinary incontinence: User research, Material selection, conceptualization and idea generation and authoring design input documents. Modelling and analyzing the physiology and mechanism of erectile dysfunction to assist device development. Design calculation and solutions to avoid catheter-associated urinary tract infection.
- Developed CAD models of the concepts using SolidWorks

Journal Articles

Parakkal Unni, Midhun, Prathyush P Menon, Lorenzo Livi, Mark Wilson, William R Young, Helen M Bronte-Stewart, and Krasimira Tsaneva-Atanasova (2020). "Data-Driven Prediction of Freezing of Gait Events from Stepping Data". In: *Frontiers in Medical Technology* 2, p. 13.

Parakkal Unni, Midhun, Prathyush P Menon, Mark R Wilson, and Krasimira Tsaneva-Atanasova (2020). "Ankle Push-off Based Mathematical Model for Freezing of Gait in Parkinson's Disease". In: *Frontiers in bioengineering and biotechnology* 8, p. 1197.

Unni, Midhun P, Aniruddha Sinha, Kingshuk Chakravarty, Debatri Chatterjee, and Abhijit Das (2017). "Neuromechanical Cost Functionals Governing Motor Control for Early Screening of Motor Disorders". In: *Frontiers in bioengineering and biotechnology* 5, p. 78.

Conference Papers

Unni, Midhun P, M Girish Chandra, and A. Anil Kumar (2017). "Memory Reduction for Numerical Solution of Differential Equations Using Compressive Sensing". In: *13th IEEE Colloquium on Signal Processing and its Applications (CSPA 2017)*.

Unni, Midhun P, Srinivasan Jayaraman, and Balamuralidhar P (2016). "Non-invasive Blood Pressure estimation using constitutive model from the radial artery pulse". In: *2nd International Conference on Biomedical Systems, Signals and Images*, p. 4.

Unni, Midhun Parakkal, Jayaraman Srinivasan, and P. Balamuralidhar (2017). "A Model Based Inference Engine for Stress Estimation". In: *2017 International Conference on Signals and Systems (ICSigSys) (ICSigSys2017)*. IEEE, pp. 234–238.

Patents

Jayaraman, Srinivasan, Balamuralidhar Purushothaman, Midhun P Unni, Aniruddha Sinha, Arpan Pal, and Ramesh Kumar Ramakrishnan (Mar. 2017). *Method and device for continuous blood pressure monitoring and estimation*. US Patent App. 15/255,643, (The corresponding patent has been granted in EU and China (EP3138482B1 and CN106491108B)).

Unni, Midhun Parakkal, Srinivasan Jayaraman, and Balamuralidhar Purushothaman (Jan. 2021). *Method and system for estimation of stress of a person using photoplethysmography*. US Patent 10,881,345.

Unni, Midhun Parakkal, Aniruddha Sinha, Kingshuk Chakravarty, Debatri Chatterjee, and Abhijit Das (Apr. 2019). *Systems and methods for optimizing a joint cost function and detecting neuro muscular profiles thereof*. US Patent App. 16/159,245.