# **Matto Leeuwis**

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in Matto Leeuwis | 🕥 mleeuwis | 🗗 Matto Leeuwis | © 0009-0009-8728-0589

Delft, Netherlands

### RESEARCH STATEMENT

I study human movement through the lens of robotics, biomechanics, and sensorimotor neuroscience. My work explores how the nervous system interacts with the body and environment to generate skilled, adaptable behavior. Using tools such as a robotic balance simulator, I investigate how humans learn altered control dynamics, ranging from small perturbations to the complete reversal of postural control. In parallel, I use musculoskeletal models to simulate and measure the energetic cost of human posture and gait, aiming to determine whether simple models accurately describe human movement and physiology. In other applied work, I developed a dynamic model of a wheelchair that could be pushed from the side for improved social interaction. By examining motor control from a dynamic systems perspective, I aim to uncover fundamental principles in biological or engineered systems that enable us to move with intelligence and purpose.

**Research interests:** Cost functions that define human movement, Development of (Bio)Robotic systems, Model-based hypotheses for how the brain realizes intelligent control, Biomechanical/Multibody simulations, Inference, Embodiment and agency

### **EDUCATION**

### • PhD Candidate Sensorimotor Neuroscience and Biorobotics

Feb 2022 - Feb 2026

Erasmus MC

Rotterdam, Netherlands [

- Dissertation (in preparation): Optimality of the human balance controller: the biomechanical and neural principles that define how we stand.
- Perform human subject experiments using a robotic balance simulator and various methods such as optical motion capture, electric vestibular stimulation, and indirect calorimetry.
- Write scientific papers and present work at various conferences on neuroscience and movement control.
- Teach and supervise students at internship, BSc, and MSc levels.
- Projects:
  - \* Contextual inference in balance: Published in PNAS; investigated associative learning and sensory-evoked balance responses under contextual control manipulations.
  - \* *Energy optimality in postural control:* Lead study on metabolic cost using motion capture experiments and musculoskeletal simulations. Assess the influence of whole-body lean, gait initiation intention, variability evoked by electrical vestibular stimulation, and postural asymmetry on balance control.
  - \* *Transformations of postural control:* Lead ongoing study on learning and adaptation to kinetic and kinematic control transformations using the robotic balance simulator.
  - \* Cortical markers of balance engagement: EEG-based study on whether cortical balance responses depend on active balance control using robotic balance simulator.
  - \* Age-related gait energetics: Compare energy expenditure and vestibular contributions in young and older adults during overground and treadmill walking.

# • MSc Mechanical Engineering (BioMechanical Design)

Sep 2019 - Jan 2022

Delft University of Technology

Delft, Netherlands

• Grade: 8.1

 Dissertation: The Dynamics of Non-upright Castor Wheels and Their Application for Pushing Wheelchairs from the Side

# • BSc Exchange Semester

2018 - 2019

University of Michigan - Shanghai Jiao Tong University Joint Institute

Shanghai, China

• Grade: 9.0 (Cum Laude)

• Followed courses on optimization and biomedical instrumentation design.

### BSc Mechanical Engineering

2016 - 2019

Delft University of Technology

Delft, Netherlands

• Grade: 8.0 (Cum Laude)

# **PROJECTS**

# • Wheelchair Design for Improved Social Interaction

Sep 2020 - Sep 2024

Ziggy Mobility, Rijndam Rehabilitation, Erasmus MC, and Delft University of Technology

Delft, Netherlands [ )

- Investigated the use of a modified castor wheel to enable pushing a wheelchair from the side by developing a 3D multibody model of the wheelchair and castor wheel.
- Work directly contributed to the founding of the startup Ziggy Mobility.
- Co-inventor on the resulting patent for Dutch jurisdiction.
- Published the study in PLOS ONE as the first and corresponding author.

# • Lead Experimentation for Development of Mechanical Ventilator

May 2020 - Aug 2020

Project Inspiration and Delft University of Technology

Delft, Netherlands [\(\psi\)]

- Worked on the development of rapidly manufacturable ventilator system for COVID-19 patients with impaired breathing.
- Tested the device according to the UK emergency ventilator standards.
- $\circ$  Designed modification for the device to reduce peaks in inspiratory pressure.

### PROFESSIONAL EXPERIENCE

### • Teaching Assistant

Sep 2020 - Jan 2022

Delft University of Technology

Delft, Netherlands [\( \big) \)

- Full-time teaching assistant for the second-year Mechanical Engineering course Rigid Body Dynamics for the academic years of 2020/2021 and 2021/2022 (Organizer: Heike Vallery).
- Developed Python code for automatically scheduling and grading weekly test results for >600 students.

# Student Engineer

Apr 2019 - Feb 2020

Tromp Bakery Solutions

Gorinchem, Netherlands [ )

- Inspected production lines and CAD models to document potential hazards and proposed solutions following ISO norms.
- Performed statics calculations in Microsoft Excel to select gas springs for production lines.

### Student Computer Aided Design Drafter

Aug 2017 - Sep 2017 & Mar 2019 - Jan 2020

Nidec Netherlands

Sliedrecht, Netherlands [�]

- Created assembly manual using SolidWorks models for high-power freestanding drives.
- Created CAD drawings and animations of multi-motor drive solutions (electric or electric-diesel hybrid) for maritime vessels.

# **PUBLICATIONS**

Jansen, Daphne, Lucas Mensink, **Leeuwis, Matto**, and Patrick A. Forbes. "Cortical responses to balance perturbations persist without active postural control". In: *In preparation* (2025).

**Leeuwis, Matto**, Nikki van Aerts, Ajay Seth, and Patrick A. Forbes. "The energetic cost of human standing balance and gait initiation over a range of natural postures". In: *Submitted* (2025).

**Leeuwis, Matto**, Job Sesink, Lucy Bennett, Emma Schippers, Marieke W. Vassen, Bram T. Sterke, Katherine L. Poggensee, and Heike Vallery. "A slanted castor wheel enables pushing manual wheelchairs from the side to improve social interaction". In: *PLOS ONE* 19.9 (2024), e0307759. URL: https://doi.org/10.1371/journal.pone.0307759.

**Leeuwis, Matto**, Yomna Asar, Joshua J. White, Brandon G. Rasman, and Patrick A. Forbes. "Different mechanisms of contextual inference govern associatively learned and sensory-evoked postural responses". In: *Proc Natl Acad Sci U S A* 121.32 (2024), e2404909121. URL: https://doi.org/10.1073/pnas.2404909121.

### **PATENTS**

Leeuwis, Matto, Lucy Bennett, and Job Sesink. "Wheelchair". NL2033392B1. 2024. URL: https://worldwide.espacenet.com/patent/search/family/084331279/publication/NL2033392B1?q=pn% 3DNL2033392B1.

### **CONFERENCE PRESENTATIONS**

- Leeuwis, Matto, Lucas Mensink, Ben Rupprecht, Chris J. Dakin, Jean Sebastien Blouin, and Patrick A. Forbes. "Can humans stand in inverted control? Learning of a non-biomimetic postural task". In: *Unconventional Robots Symposium*. 2025.
- Leeuwis, Matto, Nikki van Aerts, Ajay Seth, and Patrick A. Forbes. "Metabolic energy expenditure in quiet standing and gait initiation is similar over a wide range of postures". In: *International Society of Posture and Gait.* 2025.
- **Leeuwis, Matto**, Lucas Mensink, Jean-Sébastien Blouin, Chris J. Dakin, and Patrick A. Forbes. "Reversing postural control". In: *Dynamic Walking*. 2025. URL: https://www.youtube.com/watch?v=RUoZwT5cJbQ.
- **Leeuwis, Matto**, Yomna Asar, Joshua J. White, Brandon G. Rasman, and Patrick A. Forbes. "Human sensorimotor systems asses contextual relevance in parallel". In: *NWO Life*. 2024.
- **Leeuwis, Matto**, Nikki van Aerts, Ajay Seth, and Patrick A. Forbes. "Optimality and energy expenditure in standing and walking". In: *European Motor Control Meeting*. 2024.
- **Leeuwis, Matto**, Ajay Seth, and Patrick A. Forbes. "Musculoskeletal modeling of static standing balance suggests that metabolic costs are not minimized". In: *Neural Control of Movement*. 2023.

### MEDIA COVERAGE

• How we maintain balance turns out to be more complex than thought

Aug 2024

Featured on Amazing Erasmus MC

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### **SKILLS**

- Experimental Methods: Optical motion capture (Qualisys, Vicon), Metabolic analysis (Gas exchange measurement; COSMED, ViaSys), Electromyography (EMG), Electrical vestibular stimulation (EVS/SVS), Electroencephalography (EEG; TMSi), Force plate (AMTI, Kistler), Classical conditioning, Dutch research ethics proposals (METC, HREC)
- Modeling and Simulation: Musculoskeletal modeling (OpenSim, Scone), Multibody dynamics, State-space modeling, Optimal control, Numerical optimization (e.g., particle filter, genetic algorithm), Metabolic cost estimation, Vehicle/tire dynamics
- Programming and Analysis: MATLAB, LabVIEW, Python, BASH, Version control (Git, GitHub, GitLab, Markdown), EEGLab, Scientific computing (numerical optimization, signal processing, real-time computation), Statistics (Frequentist and Bayesian)
- **Design and Prototyping:** Mechanical Engineering, Iterative design, CAD (SolidWorks, GrabCad), 3D Printing (Cura, Ender 3), Freehand sketching
- **Scientific Communication:** Scientific writing (L<sup>A</sup>T<sub>E</sub>X, Word), Figure creation (Affinity Designer/Photo, Adobe Illustrator/Photoshop, Inkscape, MATLAB)
- **Project Management and Knowledge Tools:** EndNote, BibTeX, Zotero, Mendeley, Obsidian, Notion, Overleaf, Brightspace

# **HONORS AND AWARDS**

# Finalist Young Medical Delta Thesis Awards 2022

Oct 2022

Young Medical Delta

Stichting Fonds Bemolt

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- Presented work among three other finalists competing for the best MSc Thesis award.
- Fonds Bemolt Scholarship 2018

2018 [**(**)]

• Awarded to excelling students from Dordrecht pursuing scientific education abroad.

### TEACHING AND SUPERVISION EXPERIENCE

### Teaching and Guest lectures

Erasmus MC and TU Delft

- Erasmus MC, BSc Medicine, Various courses from 2022 to 2025 (Organizer: Johan Pel, Patrick Forbes):
  Practicals for courses on Exercise physiology, Blood circulation, Biomechanics, Echo, and Eye movements.
- TU Delft, MSc Mechanical Engineering, course Musculoskeletal Modeling and Simulation 2023-2024 (ME41006, Organizer: Ajay Seth): Mentor for eight student groups on proposed project "The effect of subject-specific parameters on standing balance outcomes."

- TU Delft, Programming Foundations 2025 (NB1035, Organizer: Nina Šoštarić): Automating experimental analysis using scientific programming
- Erasmus MC, NeuroAI: The Computing Brain Minor 2024 and 2025 (Organizer: Mario Negrello): What does it mean to move?
- Erasmus MC, Research Master Neuroscience 2025 (Organizer: Gerard Borst): Introduction to the vestibular system
- Erasmus MC, Nanjing University (NJU) Summer School 2024 (Organizer: Zhenyu Gao): Optimality and energy expenditure in standing and walking
- 4 Internal department talks for the Erasmus MC Neuroscience Department

### Supervision

Erasmus MC and TU Delft



- 4 MSc projects (Ben Rupprecht, Ralf Rienks, Daphne Onderwater, and Yomna Asar)
- 2 Internship projects (Daphne Onderwater, Timo Vanderhave)
- 2 Honors projects (Paul de Jongh, Job Sesink)
- 3 BSc Final projects (Nikki van Aerts, Job Sesink & Emma Schippers & Marieke Vassen, Inez Miedema & Valentijn Sohier)

### **ACADEMIC SERVICE**

#### Peer Reviewer

Various journals



- PLOS ONE Reviewed 1 publication and its revised version.
- Royal Society Interface Co-reviewed 1 publication and its revised version.

### Conference Moderator

Jul 2021

IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2021)



 Moderator for virtual parallel sessions; introduced speakers and facilitated general discussion after presentations.

# **ADDITIONAL INFORMATION**

Languages: Dutch, English

**Personal interests:** Martial arts (Secretary for Board 30 of Delftse Budo Sport Vereniging D.S.B.V. Yoroshi, 2019/2020), Bouldering, Tinkering (3D printing, Arduino, Desktop computer), Video game physics and design

### REFERENCES

### 1. Patrick A. Forbes

Associate Professor, Department of Neuroscience

Erasmus MC

Email: p.forbes@erasmusmc.nl Relationship: PhD Supervisor

### 2. Heike Vallery

Professor, Institute of Automatic Control

**RWTH Aachen University** 

Email: h.vallery@irt.rwth-aachen.de

Relationship: MSc thesis supervisor, collaborator on wheelchair study

# 3. Ajay Seth

Associate Professor, Department of Biomechanical Engineering

Delft University of Technology

Email: a.seth@tudelft.nl

Relationship: Collaborator on musculoskeletal modeling study

### 4. Maarten Frens

Professor, Department of Neuroscience

Erasmus MC

Email: m.frens@erasmusmc.nl Relationship: PhD Promotor