Debate: Computational approaches to studying locomotion disorders: NMSM vs. AI

Digital revolution is impacting human movement biomechanics. So far it is unclear which one has the highest potential to revolutionize the use of biomechanical assessment of movement disorders within the clinical context.

On the one hand, artificial intelligence (AI) techniques have found an attractive playground in the large biomechanical data sets available to biomechanists. As such, they have been highly useful in biomechanical finger printing of patients, facilitating classification of treatment responders and non-responders. Furthermore, AI techniques are revolutionizing data processing and becoming instrumental in bringing biomechanics into more ecological settings, allowing prediction of quantities that so far required measurements in confined and highly instrumented laboratory spaces (e.g., ground reaction forces).

On the other hand, neuromusculoskeletal modeling (NMSM) techniques have evolved in complexity from approximating simple 2D equations of motion to describing 3D structures with highly complex personalized geometry. Through dedicated parameter identification and optimization techniques, the adoption of digital twin technology for locomotor disorders, which now even accounts for personalized motor control strategies, seems to be the logical next step. The intriguing insights derived from the mechanistic cause-and-effect relationships provided by physics-based simulations appeal to the imagination as they forecast the potential to perform in silico treatment selection with the highest potential of functional benefit to the individual patient.

In this debate, we will make the case for each approach taking the lead in human movement biomechanics in the future. Join us to hear the arguments of current field leaders on the pros and cons of each approach, how the field may be shaped by them in upcoming years, and the role you may play in taking the best of these approaches to move the field forward.

1. David Lloyd

https://experts.griffith.edu.au/18616-david-lloyd

Short Bio:

David is a Biomechanical Engineer in the School of Allied Health Sciences, Griffith University, Australia. He has a BSc (Merit) (1984) in mechanical engineering from the University of New South Wales (UNSW), Australia, and first worked in the aeronautical industry. He then completed a PhD in Biomechanical Engineering (UNSW, 1993) after which he received a prestigious NIH Fogarty International Post-doctoral fellowship (1993-1995) in computational biomechanics and neurophysiology at the premier Rehabilitation Institute of Chicago and Northwestern Medical School. David is now co-founder and Director of the Griffith Centre of Biomedical and Rehabilitation Engineering (GCORE), Menzies Health Institute Queensland. GCORE is an alliance between Griffith University, the Gold Coast University Hospital and other hospitals on the Gold Coast and in Brisbane, and various industry partners. David was co-founder of Griffith's Advanced Design and Prototyping Technologies Institute (ADaPT), and leads ADaPT Medical. He has supervised 44 PhD's to completion, and published more than 260 fully refereed scientific articles (>16800 citations, h-index 67, in Google Scholar), with over 320 refereed conference abstracts. David's as CI and co-CI has received more than $AUD34 Million in research funding, yielding many honours and awards that include an elected Fellow of the International Society of Biomechanics, member of Faculty 1000, recipient of the 2020 Geoffrey Dyson Award by the International Society of Biomechanics in Sport, and ranked The Australian 2019 Field Leader in Biophysics. David and team have developed biophysical and AI computer computer simulation methods to study the causes, prevention, and management of various neuromusculoskeletal conditions. These methods and technologies are now being adopted worldwide in laboratories, orthopaedics and neurorehabilitation industries. David and team are currently developing accurate personalised digital twins of humans and devices that operate in real-time by combining data from laboratory-based instrumentation, multimodal medical imaging and wireless wearable devices. These technologies are being applied to a range of medical diagnostics and devices including personalised surgical planning, implant design and manufacture, and assistive devices.

2. Eni Halilaj

https://www.meche.engineering.cmu.edu/bios/halilaj-eni

Short Bio:

Dr. Eni Halilaj is an Assistant Professor of Mechanical Engineering, Biomedical Engineering, and the Robotics Institute at Carnegie Mellon University. She also holds an adjunct appointment in Orthopaedic Surgery at the University of Pittsburgh School of Medicine. Dr. Halilaj currently directs the CMU Musculoskeletal Biomechanics Lab, which combines medical imaging, motion capture in laboratory settings and natural environments, computational modeling, and machine learning to study the implication of movement mechanics in orthopaedic pathologies, such as osteoarthritis. Her ultimate goal is to integrate insights from her group's experimental and computational work in the development of precision rehabilitation technologies aimed at restoring and preserving pain-free mobility in people at risk for primary and post-traumatic osteoarthritis.

3. Ilse Jonkers

https://esbiomech.org/welcome-to-the-european-society-of-biomechanics-esbiomech/council/scientific-communications/

Short Bio:

From my PhD onwards, I successfully bridged from a classical human movement science and physical therapy profile towards an integrated biomedical science and biomedical engineering profile, to advance the understanding of pathological movement, its effect on musculoskeletal, joint and cartilage tissue loading as well as cartilage homeostasis, degeneration and repair. I am confident that these fundamental insights into cartilage mechano-biology will define the corner stones of future rehabilitation and exercise programs that effectively target optimal cartilage health.

My group is conducting internationally highly competitive research and has produced leading and important contributions on the quantification of whole joint loading using multi-body simulation. Its work is known for the development of subject-specific musculoskeletal models containing a high level of anatomical detail to study children with cerebral palsy and degenerative joint disease. More recent research activities relate to cartilage mechanobiology, more specific the development of multi-scale modelling of bone and cartilage adaptation, bioreactor-based evaluation of loading-induced molecular cartilage adaptation and advanced medical imaging of cartilage.

In conclusion, integrating biomedical and engineering science, my research is highly multi-disciplinary by nature with the ultimate aim of fully exploiting a hybrid experimental and computer modelling approach to address fundamental and clinical questions where a biomechanist's perspective can make a difference.