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Wearable and Wireless Systems for Healthcare II

Movement Disorder Evaluation and Deep Brain Stimulation Systems



Smart Sensors, Measurement and Instrumentation

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Wearable and Wireless Systems for Healthcare II

Movement Disorder Evaluation and Deep Brain Stimulation Systems



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In Memoriam:

Timothy Mastroianni's Mother and Father:

Adele Teresa Blackburn (1920–2018) John Charles Blackburn (1919–1992)

I'd like to express my deep appreciation to my parents, John Charles Blackburn and

Adele Teresa Blackburn, for supporting all of my early ideas and inventions without

question, which gave me the freedom to

experiment. They have guided me, inspired me, encouraged me, and sustained me. Most

of all, they have always believed in me. It is to them that this book is dedicated.

David Peduto (Lt. Col. US Army)

(1954–2016)

To a friend, valued research team member, and patriot.

Professor Warren S. Grundfest, MD, FACS (1952–2018)

(and the Committee Chair for the Ph.D.

Dissertation of Dr. Robert LeMoyne) Thank you. To my Wife, thank you for everything. Love Always.

I would like to thank my Mother, Father, and Brother for their support.

"Nothing transcends the power of the human spirit."

from a homeless Vietnam Veteran and very loyal friend

And in the wind, he's still alive.
"To heat a tiger one needs a brother's help'

"To beat a tiger, one needs a brother's help."

Chinese Proverb

Thanks Tim.

Chiri mo tsumoreba yama to naru.

A favorite Japanese Proverb (in Romaji)

Translation:

Even dust piled up becomes a mountain.

Preface

The domain of wearable and wireless systems for biomedical and movement disorder treatment applications, such as through smartphones and portable media devices, is anticipated to grow exponentially. Even from the time of presenting the draft manuscript of this book to the time of publication, the prevalence of this subject is expected to undergo meaningful transformation and evolution. These devices enable wireless inertial sensor applications to an assortment of scenarios pertaining to movement disorder evaluation and deep brain stimulation systems.

Since 2010, when LeMoyne, Mastroianni, and our research team applied a novel smartphone application for quantifying Parkinson's disease tremor and gait quantification in the context of a wireless accelerometer, the opportunities have expanded considerably. The authors are delighted to provide a contribution to this exciting field with the anticipation of the considerable array of developments in years to follow. Please enjoy the knowledge and intellectual inspiration that our book provides with the goal of providing meaningful, robust, and optimal rehabilitation for many.

Flagstaff, AZ, USA Pittsburgh, PA, USA Robert LeMoyne Timothy Mastroianni Donald Whiting Nestor Tomycz

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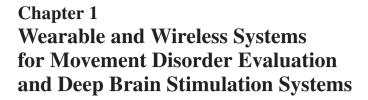
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Abstract The implementation of wearable and wireless systems for deep brain stimulation offers the opportunity to substantially advance the treatment of progressive neurodegenerative movement disorders, such as Parkinson's disease and Essential tremor. Deep brain stimulation offers an efficacious alternative regarding scenarios for which the intervention by medication has become intractable while avoiding the permanency of ablative neurosurgery. Even subsequent to the expert surgical application of the deep brain stimulation system, the acquisition of the optimal parameter configuration is inherently resource intensive and challenging in nature. With the advent of wearable and wireless systems, the response to therapy intervention for movement disorder status can be objectively quantified through the inertial sensor signal, such as an accelerometer and gyroscope. Furthermore, wireless connectivity to the Internet enables experimental and post-processing resources to be remotely situated effectively anywhere in the world. With machine learning amended to the post-processing capability, clinical diagnostic acuity is substantially advanced. Foundational subjects are elucidated, such a general perspective regarding Parkinson's disease and Essential tremor, traditional ordinal methodologies for diagnosing severity, and the development of deep brain stimulation including surgical techniques for installation. The role of wearable and wireless systems, such as the smartphone, for quantifying the status of neurodegenerative movement disorders, such as Parkinson's disease and Essential tremor, is presented. The utility of applying machine learning for augmenting diagnostic acuity of movement disorder status is addressed. The integration of wearable and wireless systems, such as the smartphone, with machine learning is discussed for the ability to distinctively classify between deep brain stimulation set to "On" and "Off" status for Parkinson's disease and Essential tremor. The amalgamation of wearable and wireless systems with deep brain stimulation using machine learning as an augmented post-processing application implicate the evolutionary trends for the ability to achieve closed-loop optimization of parameter configurations with the development of Network Centric Therapy for a quantum leap in the treatment intervention for neurodegenerative movement disorders, such as Parkinson's disease and Essential tremor.