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Robert LeMoyne
Timothy Mastroianni
Donald Whiting
Nestor Tomycz

Wearable and Wireless Systems for Healthcare II

Movement Disorder Evaluation and Deep Brain Stimulation Systems

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Subhas Chandra Mukhopadhyay
Department of Engineering, Faculty of Science and Engineering
Macquarie University
Sydney, NSW
Australia
e-mail: subhas.mukhopadhyay@mq.edu.au

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Robert LeMoyne
Department of Biological Sciences and
Center for Bioengineering Innovation
Northern Arizona University
Flagstaff, AZ, USA

Donald Whiting
Department of Neurosurgery Allegheny
General Hospital
Allegheny Health Network Neuroscience
Institute
Pittsburgh, PA, USA

Timothy Mastroianni
Independent
Pittsburgh, PA, USA

Nestor Tomycz
Department of Neurosurgery Allegheny
General Hospital
Allegheny Health Network Neuroscience
Institute
Pittsburgh, PA, USA

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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 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

Contents

1 Wearable and Wireless Systems for Movement Disorder Evaluation and Deep Brain Stimulation Systems 1
1.1 Introduction 2
1.2 Perspectives of the Chapters 3
1.2.1 Perspective of Chap. 2: Movement Disorders: Parkinson's Disease and Essential Tremor—A General Perspective 3
1.2.2 Perspective of Chap. 3: Traditional Ordinal Strategies for Establishing the Severity and Status of Movement Disorders, Such as Parkinson's Disease and Essential Tremor 4
1.2.3 Perspective of Chap. 4: Deep Brain Stimulation for the Treatment of Movement Disorder Regarding Parkinson's Disease and Essential Tremor with Device Characterization 4
1.2.4 Perspective of Chap. 5: Surgical Procedure for Deep Brain Stimulation Implantation and Operative Phase with Postoperative Risks 5
1.2.5 Perspective of Chap. 6: Preliminary Wearable and Locally Wireless Systems for Quantification of Parkinson's Disease and Essential Tremor Characteristics 6
1.2.6 Perspective of Chap. 7: Wearable and Wireless Systems with Internet Connectivity for Quantification of Parkinson's Disease and Essential Tremor Characteristics 6
1.2.7 Perspective of Chap. 8: Role of Machine Learning for Classification of Movement Disorder and Deep Brain Stimulation Status 7

1.2.8 Perspective of Chap. 9: Assessment of Machine Learning Classification Strategies for the Differentiation of Deep Brain Stimulation "On" and "Off" Status for Parkinson's Disease Using a Smartphone as a Wearable and Wireless Inertial Sensor for Quantified Feedback 8
1.2.9 Perspective of Chap. 10: New Perspectives for Network Centric Therapy for the Treatment of Parkinson's Disease and Essential Tremor 9
1.3 Conclusion 10
References 11

2 Movement Disorders: Parkinson's Disease and Essential Tremor—A General Perspective 17
2.1 Introduction 18
2.2 Parkinson's Disease 18
2.3 Essential Tremor 18
2.4 Traditional Strategies for Assessing Progression and Treatment of Parkinson's Disease and Essential Tremor 19
2.5 Advanced Strategies for Assessing Progression and Treatment of Parkinson's Disease and Essential Tremor 20
2.6 Extrapolation to Network Centric Therapy 21
2.7 Conclusion 21
References 22

3 Traditional Ordinal Strategies for Establishing the Severity and Status of Movement Disorders, Such as Parkinson's Disease and Essential Tremor 25
3.1 Introduction 26
3.2 Clinical Assessment of Parkinson's Disease 26
3.3 Clinical Assessment of Essential Tremor 30
3.4 Wearable and Wireless Systems for the Quantification of Movement Disorder Tremor 30
3.5 Extrapolation to Network Centric Therapy 32
3.6 Conclusion 32
References 33

4 Deep Brain Stimulation for the Treatment of Movement Disorder Regarding Parkinson's Disease and Essential Tremor with Device Characterization 37
4.1 Introduction 38
4.2 The Foundations of Deep Brain Stimulation 38
4.3 Long-Term Efficacy and the Quest to Define the Mechanisms of Deep Brain Stimulation 39
4.4 Benefit and Risk Consideration of Deep Brain Stimulation 40

4.5 Target Selection for Deep Brain Stimulation 40
4.5.1 Essential Tremor 40
4.5.2 Parkinson's Disease 40
4.6 Deep Brain Stimulation System Device Description 41
4.6.1 Electrode Leads and the Implantable Pulse Generator 42
4.6.2 Battery 44
4.6.3 Electrical Signal 45
4.7 Deep Brain Stimulation System Programmer 45
4.8 Attaining the Optimal Parameter Configuration for Deep Brain Stimulation an Issue with Tuning 46
4.9 Future Perspectives for Deep Brain Stimulation 47
4.10 Conclusion 48
References 49

5 Surgical Procedure for Deep Brain Stimulation Implantation and Operative Phase with Postoperative Risks 53
5.1 Introduction 53
5.2 General Surgical Perspective and Considerations for the Application of Deep Brain Stimulation 54
5.3 Deep Brain Stimulation Operative Risks and Complications 55
5.4 Postoperative Risk Regarding Energy Interaction 56
5.5 Adverse Neurological and Neuropsychological Effects for Deep Brain Stimulation 58
5.6 Operative Technique Advocated by Allegheny General Hospital 58
5.7 Applied Deep Brain Stimulation Programming from by Allegheny General Hospital 60
5.8 Conclusion 62
References 62

6 Preliminary Wearable and Locally Wireless Systems for Quantification of Parkinson's Disease and Essential Tremor Characteristics 65
6.1 Introduction 65
6.2 Preliminary Applications for Accelerometers Quantifying Parkinson's Disease 66
6.3 Wireless Accelerometer Feedback for Optimal Tuning of Deep Brain Stimulation Parameter Settings: A Conceptual Perspective 68
6.4 Preliminary Demonstration of Wearable and Wireless Accelerometer Systems for Quantifying Parkinson's Disease Tremor 70
6.5 Evolution of Wearable and Wireless Systems: From Local Wireless Connectivity to Internet Connectivity 73
6.6 Conclusion 76
References 76

7 Wearable and Wireless Systems with Internet Connectivity for Quantification of Parkinson's Disease and Essential Tremor Characteristics 79
7.1 Introduction 80
7.2 Smartphone for Quantifying Parkinson's Disease Hand Tremor 80
7.3 Smartphone for Quantification of Essential Tremor Regarding Deep Brain Stimulation in "On" and "Off" Mode 87
7.4 Smartwatches, Bluetooth Wireless Connectivity, and Other Wearable and Wireless Systems for the Quantification of Movement Disorder Status 91
7.5 Network Centric Therapy 94
7.6 Conclusion 95
References 96

8 Role of Machine Learning for Classification of Movement Disorder and Deep Brain Stimulation Status 99
8.1 Introduction 99
8.2 Waikato Environment for Knowledge Analysis (WEKA) for Machine Learning Classification of Movement Disorder Ameliorated Through Deep Brain Stimulation Using Wearable and Wireless Systems for Quantified Feedback 100
8.2.1 J48 Decision Tree 104
8.2.2 K-Nearest Neighbors 105
8.2.3 Logistic Regression 106
8.2.4 Support Vector Machine 106
8.2.5 Multilayer Perceptron Neural Network 106
8.2.6 Random Forest 107
8.2.7 Attribute-Relation File Format (ARFF) 107
8.3 The Role of Machine Learning for Network Centric Therapy 108
8.4 Conclusion 109
References 110

9 Assessment of Machine Learning Classification Strategies for the Differentiation of Deep Brain Stimulation "On" and "Off" Status for Parkinson's Disease Using a Smartphone as a Wearable and Wireless Inertial Sensor for Quantified Feedback 113
9.1 Introduction 114
9.2 Background 115
9.3 Method and Materials 116
9.4 Results and Discussion 118

9.5 Network Centric Therapy Integrating Wearable and Wireless Systems as Quantified Feedback for Deep Brain Stimulation Using Machine Learning Classification 122
9.6 Conclusion 124
References 125

10 New Perspectives for Network Centric Therapy for the Treatment of Parkinson's Disease and Essential Tremor 127

Chapter 1
Wearable and Wireless Systems for Movement Disorder Evaluation and Deep Brain Stimulation Systems

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.

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