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A WIRELESS MULTICHANNEL NEURAL RECORDING
PLATFORM FOR REAL-TIME BRAIN MACHINE
INTERFACES

by

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Dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy
in the Department of Biomedical Engineering
in the Graduate School of
Duke University

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ABSTRACT

(Biomedical Engineering)

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Abstract

Recent technological advances attempting to interface prosthetic limbs to the brain have been hampered by a lack of wireless multichannel data acquisition hardware. This work has attempted to fill that void by developing a portable recording platform for up to 16 chronically implanted cortical electrodes. The system consists of (1) an analog “Headstage” integrated circuit for buffering and amplifying the electrode signals (2) a low power analog front end (AFE) for conditioning and digitizing the neural signals, and (3) a digital back end for transmitting either the raw neural signals, or only the action potential waveforms. The 16-channel Headstage used a non-inverting feedback architecture to achieve tightly matched gains ($\mu = 1.99$) and an input referred noise of $10\mu V_{rms}$. The 16-channel AFE featured variable gain, 4th order Bessel bandpass filtering, and a reference matrix for selectable bipolar recordings. The digital back end consisted of a programmable logic device for detecting spikes, a FIFO memory for queuing the data, and a wearable PC fitted with an 802.11b Ethernet card for transmitting the data over a UDP network protocol. The system measures $5.1 \times 8.1 \times 12.4cm$, weighs 235g (including batteries), and is capable of transmitting 12 channels of 8-bit raw data simultaneously over nine meters. *In vivo* recordings demonstrated that signals acquired with this system were of similar fidelity to those recorded by a commercial recording system. The spike detector was able to correctly detect over 90% of spikes at signal to noise ratios greater than 2.1. Detection reduced the volume of telemetered data by 97% when the mean spike firing rate was 9.3 spikes/channel/second.

A study was conducted to determine which spike detection algorithm is best suited for detecting neural spikes in a wearable system with limited computational resources. Detections were scored with a novel cost function that weighed the probabilities

of correct detections, the rates of false positive detections, and the computational demands of the detection algorithm relative to the computational capabilities of the system. The results indicated that a simple algorithm, such as taking the absolute value and applying a threshold, is as effective for computationally limited systems as more complex energy or matched filter based detectors .

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For Jodi

“We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win.”

John F. Kennedy, 1962

Contents

Abstract	iv
Acknowledgements	vi
List of Figures	xv
List of Tables	xviii
1 Introduction	1
1.1 Brain Machine Interface Overview	1
1.1.1 BMI Signal Sources	2
1.1.2 Feedback	5
1.2 Electrode Implantation Surgery	5
1.2.1 Implantation	5
1.2.2 Physical Stabilization	6
1.3 Electrodes	7
1.3.1 Microwires	7
1.3.2 Michigan Electrode Arrays	8
1.3.3 Ceramic Electrode Arrays	8
1.3.4 Utah Electrode Array	8
1.4 Signal Transduction	9
1.4.1 Electrode-Neuron Geometry	9
1.4.2 Multiple Neurons per Electrode	10
1.5 Signal Quality	10
1.5.1 Electrode Impedance	11

1.5.2	Offset	11
1.6	Instrumentation	12
1.7	Wireless Brain Machine Interfaces	13
1.7.1	Limitations of Tethered Data Acquisition	13
1.7.2	Existing Systems	13
1.7.3	Commercial Wireless Technology	13
1.8	Spike Detection	14
1.9	Outline	16
2	Spike Detection	17
2.1	Introduction	17
2.2	Methods	18
2.2.1	Overview	18
2.2.2	Test Data Signals	20
2.2.3	Preprocessors	23
2.2.4	Cost Function	26
2.3	Results	28
2.3.1	Artificial Data	28
2.3.2	<i>In Vivo</i> Data	33
2.4	Discussion	35
2.4.1	Simple Threshold Preprocessors	37
2.4.2	Energy Based Preprocessors	38
2.4.3	Matched Filter Preprocessor	39
2.4.4	Cost Function	40
2.4.5	Limitations	40

2.5	Conclusion	42
3	System Design	43
3.1	Overview	43
3.2	Headstage	46
3.2.1	Block Diagram	46
3.2.2	Opamp Design	46
3.2.3	Layout	50
3.2.4	Fabrication, Packaging, and Testing	50
3.3	Analog Front End	52
3.3.1	Analog Block	53
3.3.2	Analog to Digital Conversion	55
3.3.3	Power Supply	56
3.3.4	Physical Circuit	56
3.4	Digital Back End	57
3.4.1	Digital Board	58
3.4.2	Wearable Computer	65
3.4.3	Power Supply	66
3.4.4	User Interface	67
4	System Evaluation	68
4.1	Backpack	69
4.1.1	Physical and Electrical Characteristics	69
4.1.2	<i>In Vivo</i> Examination and Evaluation	79
4.2	Spike Detection	85
4.2.1	Experimental Setup	87

4.2.2	Experimental Data	89
5	Discussion	95
5.1	Headstage	96
5.1.1	Headstage Noise	97
5.1.2	Headstage Packaging	98
5.1.3	Electrode Offset Rejection	98
5.2	Analog Front End	99
5.3	Variable Gain	101
5.4	Reference Channel Selection	102
5.5	Digital Back End	103
5.6	Digital Design	103
5.7	Latency	104
5.8	Information Transmission	105
5.9	Multipath / UDP	105
5.10	Portability	106
5.11	Spike Detection Simulations	107
5.12	Threshold Selection	108
5.13	<i>In Vivo</i> Spike Detection	109
A	AFE Equations	114
B	Nonlinear Energy Operator	118
C	Monkey Jacket	121
D	ROC Curves	126
D.1	Spike Detection - Artificial Test Data	126

D.2 Spike Detection - <i>In Vivo Test Data</i>	130
D.3 System Evaluation - <i>In Vivo Test Data</i>	135
Bibliography	137
Biography	146

List of Figures

2.1	A bank of action potentials used to create artificial neural signals for testing spike detectors	21
2.2	Sample artificial neural signals for testing spike detectors	22
2.3	Sample <i>in vivo</i> signals used for testing spike detectors	24
2.4	Families of cost function score curves for four preprocessors.	29
2.5	Cost function scores for the top five preprocessors at three different SNR levels.	31
2.6	Cost function scores for preprocessors applied to the <i>in vivo</i> test data signals.	34
2.7	Cost function scores for preprocessors applied to the <i>in vivo</i> test data signals with $w_3 = 0$ in Equation 2.1.	36
2.8	Action potentials from one <i>in vivo</i> unit are shown before and after transformation by the <i>NEO(1)</i> preprocessor.	38
2.9	Average power spectrum densities for the artificial data set and <i>in vivo</i> data set.	41
3.1	Backpack block diagram.	44
3.2	Headstage block diagram and circuit schematic for a single headstage channel	47
3.3	Opamp design used for the headstage integrated circuit.	48
3.4	Die layout for the headstage IC.	51
3.5	The overall block diagram of the 16 channel analog front end.	52
3.6	Schematic for a full analog front end channel.	54
3.7	Digital back end block diagram.	59

3.8	Block diagram describing the spike detector’s functionality.	60
3.9	DBE timing diagram.	64
4.1	Photograph showing three Headstage boards.	70
4.2	AFE bode response.	73
4.3	Photographs of the Analog Front End and Digital Back End.	77
4.4	Photographs of the completely constructed Backpack.	78
4.5	Simultaneously acquired signals from a macaque.	82
4.6	Simultaneously acquired signals from an owl monkey.	83
4.7	Comparison of neural signals recorded in parallel by both the Backpack and a the Plexon MAP.	84
4.8	Use of the reference channel selection feature to remove signal artifacts.	86
4.9	Block diagram of the hardware configuration used to test the real-time spike detection algorithm.	87
4.10	Detected spikes superimposed on the source raw data signals for a four-channel trial from the rat study ($\alpha = 3$).	91
4.11	Cost function scores for the rat study and the owl monkey study.	92
5.1	Spike detection “masking”	110
C.1	Photograph of the front view of the macaque jacket.	123
C.2	Photograph of the back view of the macaque jacket (zipper open).	124
C.3	Photograph of the back view of the macaque jacket (zipper closed).	125
D.1	ROC curves for artificial test data : (a) SNR=1.4, (b) SNR=2.2	127
D.2	ROC curves for artificial test data : (a) SNR=3.0, (b) SNR=3.8	128

D.3	ROC curves for artificial test data : SNR=4.6	129
D.4	ROC curves for the <i>in vivo</i> test data : (a) SNR=1, (b) SNR=2 . . .	131
D.5	ROC curves for the <i>in vivo</i> test data : (a) SNR=3, (b) SNR=4 . . .	132
D.6	ROC curves for the <i>in vivo</i> test data : (a) SNR=5, (b) SNR=6 . . .	133
D.7	ROC curves for the <i>in vivo</i> test data : SNR=7	134
D.8	ROC curves for the Backpack's <i>in vivo</i> tests using (a) rats, (b) owl monkeys	136

List of Tables

2.1	SNR statistics of the <i>in vivo</i> spike detection test signals	23
2.2	Clock cycles per sample required by the different preprocessors	27
2.3	Constant terms used to evaluate the cost function (Equation 2.1).	27
2.4	The five highest scoring preprocessors in each of four categories.	30
2.5	The five highest scoring preprocessors when computational complexity is disregarded	32
2.6	Signal to noise ratio gain by preprocessor	33
3.1	Device values for the headstage opamp.	49
3.2	Required control signals for the AFE	57
3.3	Autorange settings in the spike detector.	61
3.4	Summary of the predicted power consumption for each of the major components of the Backpack.	66
4.1	Electrical Characteristics of the Headstage IC.	69
4.2	Electrical characteristics of the Analog Front End.	71
4.3	Effective ADC resolution. Average number of bits per sample that were more significant than the background noise level.	75
4.4	The maximum percentage of correctly detected spikes for each of the 20 APs that were detected in the two <i>in vivo</i> spike detection studies.	93
4.5	False alarms per second detected in the <i>in vivo</i> data during trials where no action potentials occurred.	93
4.6	Data Reduction: Average file sizes of spike detected data, as a percentage of the streamed (i.e. raw) file sizes.	94

A.1	AFE Bill of Materials	115
A.2	Standardized Parameters for a fifth order Bessel low pass filter . . .	117