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Design and Implementation of Electromyographic Sensor System for Wearable Computing

Young-Seok Lee*

Abstract In this paper we implemented an EMG sensor system for wearable devices to obtain and analyze of EMG signals. The performance of the implemented sensor system is evaluated by the correlation analysis of muscle fatigue and muscle activation to clinical EMG system and compared with power consumption of the measured power of our system and commercial systems. In experiments with biceps and triceps brachii of 5 objects, The correlation values of muscle fatigue and muscle activation between our system and the clinical EMG system is 1.1~1.4 and about 1.0, respectively. And also the power consumption of our system is 25~50% less than that of some commercial EMG sensor systems.

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Key Words : EMG sensor system, Muscle activation, Muscle fatigue, Power consumption, Wearable device

1.

(healthcare)
(EMG), (ECG)
(vital
sign) 가
[1].
(Bluetooth) 2014

2.

가
,
(action potential)
가
[2].
2018 200
가 가
[3].
가
가
[4].
(stationarity) $50\mu V - 30mV$
(surface electrode)
 $0Hz - 500Hz$
 $50Hz - 150Hz$
가
(instrument amplifier)
(quality)
(trade off)가 [5].
(analog to digital converter)
(muscle fatigue)
(muscle activation)
가
가
(median frequency) f_m (root

mean square) $R(t)$,[6].

$$\int_0^{f_m} |FFT(EMG(t))| df \quad (1)$$

$$= \int_{f_m}^{\infty} |FFT(EMG(t))| df$$

(1) f_m
 가 가 1/2 가

$$R(t) = \sqrt{\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} |EMG(t)|^2 dt} \quad (2)$$

(2) 가 가

3.

가

3V

(Analog Devices company) AD623

. AD623

(rail to rail)

[7].

$$v_o = \left(1 + \frac{100k\Omega}{R_G}\right) v_i \quad (3)$$

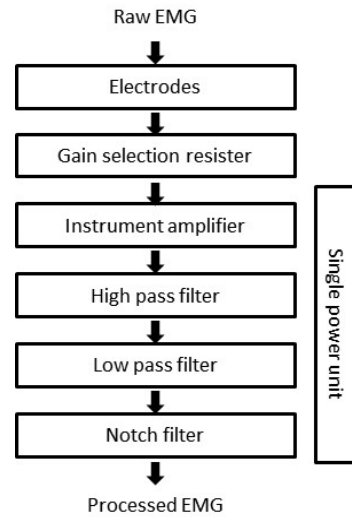
가



1. (a) Implemented Dry (b) AgCl electrode
 Fig. 1. (a) Implemented Dry (b) AgCl electrode

AD623

(3) R_G



2.

Fig. 2. Block diagram of EMG sensor system

1 (dry electrode) (AgCl) (wet electrode)

1cm

4.

가 5

(Sallen-Key) 2 (4) (5)

(biceps brachii) (triceps brachii) (isotonic exercise)

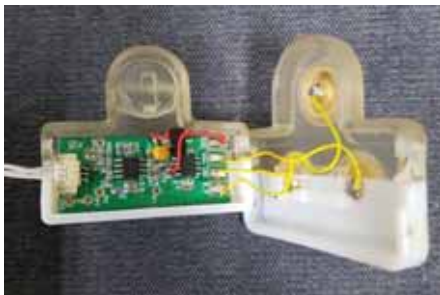
[8].

20Hz 400Hz가 (P-SPICE)

(Laxtha, model: QEMG4)

$$H_L(s) = \frac{1/R_1R_2}{s^2C_1C_2 + (C_2/R_2 + C_2/R_1) + 1/R_1R_2} \quad (4)$$

$$H_H(s) = \frac{s^2C_1C_2}{s^2C_1C_2 + (C_2/R_2 + C_1/R_2) + 1/R_1R_2} \quad (5)$$



3. (12mm×32mm)
Fig. 3. Implemented EMG sensor system

(notch)

3

가

가

12

100

1

가

2

3.3V

151015

9mA

4

BITALino EMG
가 4mA 가

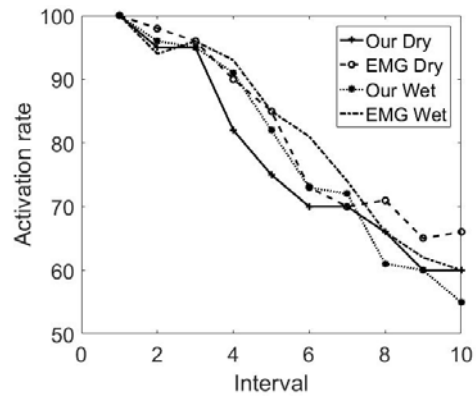
5mA,

2

1. f_m
 Table 1. Example of median frequency f_m at biceps brachii

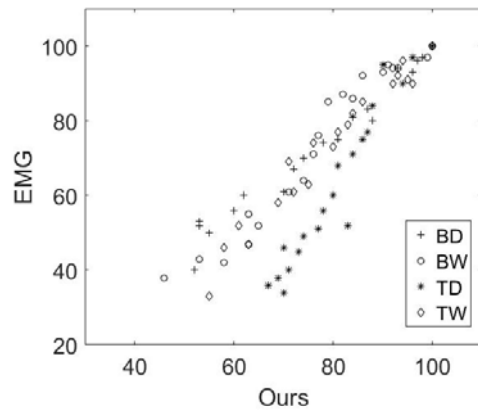
Interval	Biceps Brachii			
	Dry electrode		Wet electrode	
	Ours	Clinical sys.	Ours	Clinical sys.
1	100	100	100	100
2	98	97	99	97
3	97	96	93	94
4	96	93	91	95
5	93	94	90	93
6	94	90	92	94
7	87	83	86	92
8	88	80	84	86
9	84	81	82	87
10	81	75	79	85
11	78	74	77	76
12	74	70	76	71
13	72	67	74	64
14	70	61	71	61
15	62	60	63	55
16	60	56	65	52
17	53	52	63	47
18	55	50	58	42
19	53	53	53	43
20	52	40	46	38

가
 ('Our') ('EMG'
) 가 1.0



4. Fig. 4. Comparison of EMG activation rate

5 ('B') ('T')
 ('D') ('W')



5. Fig. 5. Correlation analysis of muscle fatigue

2. Table 2. Comparison of power consumption with commercial EMG systems

Company	Model	Current(mA)		Supply voltage
		Typ.	Max	
BITAlino	EMG151015	4	N-A	3.3V
Ours		5	9	3.3V
MyoWare	AT04001	9	14	3.3V
Delsys	Bagnoli	20	N-A	3.3V

4

10

x ('Ours') y
 ('EMG') '+'
 $y = 1.1x - 8.5$

가 1.1
 가

3. 1
 Table 3. Results of 1st curve fitting

Muscle & Electrode	Curve fit
BD	$y = 1.1x - 8.5$
BW	$y = 1.4x - 3.9$
TD	$y = 2.1x - 112.8$
TW	$y = 1.3x - 34.7$

3 5

5.

가
 가
 1/2~1/4
 가
 1.1~1.4
 , 1.0
 , 5

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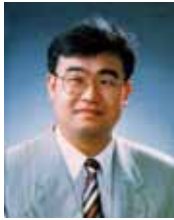
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- 1998 2 : ()
- 1998 3 ~ :

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