CrossMark

ERRATUM

Erratum to: Low stiffness design and hysteresis compensation torque control of SEA for active exercise rehabilitation robots

Wonje Choi[1] · Jongseok Won[1] · Jimin Lee[1] · Jaeheung Park[1,2]

Erratum to: Auton Robot DOI 10.1007/s10514-016-9591-z

In the original publication of the article, the following errors were occurred. These errors have been corrected with this erratum.

In Fig. 4, labels of sub-figures (b) and (c) should be changed each other, and x-axis labels 'Time (sec)' of lower two figure should be read as 'Deformation (rad)'. In Fig. 5, θ_{pre} should be read as θ_{pre}. In pages 8-9, all subscripts k should be read as i. In page 9, $\theta_a, \theta_b, \theta_c$, and θ_d should be read as $\theta_A, \theta_B, \theta_C$, and θ_D, and in Eq. 26, f_{ac} should be read as f_{dc}.

In Algorithm 1, the following typos has occurred in line numbers 8, 9, 13, 14, 15, 18 and 20. The corrected Algorithm is given below:

✉ Jaeheung Park
park73@snu.ac.kr

Wonje Choi
chwj79@snu.ac.kr

Jongseok Won
js1der@snu.ac.kr

Jimin Lee
jmpechem@snu.ac.kr

[1] Department of Transdisciplinary Studies, Seoul National University, Seoul, Republic of Korea

[2] Advanced Institute of Convergence Science and Technology, Suwon, Republic of Korea

Algorithm 1 The function of modifed backlash model for hysteresis

```
 1: function f_hys(θ)
 2:     if f_prev = f_tl and θ_tl,min ≤ θ ≤ θ_tl,max then
 3:         τ = f_tl(θ);
 4:     else
 5:         if (θ − θ_prev1) · (θ_prev1 − θ_prev2) ≥ 0 then
 6:             if (θ − θ_prev1) > 0 then
 7:                 τ = f_ac(θ);
 8:             else if (θ − θ_prev1) < 0 then
 9:                 τ = f_dc(θ);
10:             else τ = f_prev(θ)
11:             end if
12:         else θ_tp = θ
13:             if (θ − θ_prev1) < 0 then
14:                 f_tl(θ) = sθ + p,  p is solved from (23);
15:                 θ_tl,min is solution of (25);
16:                 θ_tl,max = θ_tp;
17:             else
18:                 f_tl(θ) = sθ + p,  p is solved from (26);
19:                 θ_tl,min = θ_tp;
20:                 θ_tl,max is solution of (28);
21:             end if
22:             τ = f_tl(θ);
23:         end if
24:     end if
        return τ
25: end function
```

In Table 4, the f_{al+} was misspelled in the 4th, 5th, 6th, and 7th rows of 1st column. From 4th row, f_{al+} should be read as $f_{ac+}, f_{ac-}, f_{dc+}$, and f_{dc-}. The corrected Table is given below:

Table 4 Parameters of three springs for the proposed hysteresis model

$f_{ac}(\theta)$ or $f_{dc}(\theta) = a_n\theta^n + a_{n-1}\theta^{n-1} + \cdots + a_2\theta^2 + k\theta$, $f_{lt}(\theta) = s\theta + p$

	Low stiffness (k=9.768 Nm/rad)					Medium stiffness (k=12.770 Nm/rad)					High stiffness (k=19.470 Nm/rad)						
	n	a_5	a_4	a_3	a_2	n	a_5	a_4	a_3	a_2	n	a_7	a_6	a_5	a_4	a_3	a_2
f_{ac+}	5	−2.501	8.877	−10.122	4.053	5	−10.332	27.001	−22.200	6.203	7	−1613.7	4502.2	−4798.6	2431.3	−589.9	58.4
f_{ac-}	5	2.021	6.967	8.854	4.483	5	0.440	1.188	4.019	3.525	7	−1071.2	−2486.2	−1997.3	−620.1	−47.5	4.2
f_{dc+}	5	2.438	−8.305	9.946	−4.651	5	−0.636	17.379	−12.726	1.685	7	−1322.3	3321.9	−3045.7	1239.9	−219.3	14.3
f_{dc-}	5	−4.106	−15.589	−19.281	−8.231	5	−7.19	−20.014	−17.080	−4.751	7	−1225.6	−3250.3	−3260.6	−1554.1	−364.8	−37.142
s	$s_+ = 12.551$,	$s_- = 13.176$				$s_+ = 18.977$,	$s_- = 21.211$				$s_+ = 28.332$,	$s_- = 25.464$					

In page 13, "The spring block of Fig. 12 has..." should be read as "The spring block in Fig. 12 means physical spring, and the block for the proposed model means the estimation model. The latter block has...", and "Figure 12 shows the experimental results..." should be read as "Figure 14 shows the experimental results...". In Fig. 15, the caption should be corrected as "The experiment results of torque control without external motion. **a** Reference torque trajectory. **b** Torque error for three cases."

In Eq (43) of Appendix 1, $s_{-,max}$ should be read as $s_{-,min}$ and in page 19, "where $s_{+,min}$ and $s_{,min}$ are..." should be read as "where $s_{+,min}$ and $s_{-,min}$ are...".

The Acknowledgement should be corrected following the official format of the government ministry.