

Comments and Corrections

Corrections to “A Piecewise Monotonic Smooth Phase Variable for Speed-Adaption Control of Powered Knee-Ankle Prostheses”

Teng Ma¹, Graduate Student Member, IEEE, Yuxuan Wang, Xinxing Chen², Member, IEEE, Chuheng Chen³, Zhimin Hou⁴, Graduate Student Member, IEEE, Haoyong Yu⁵, Senior Member, IEEE, and Chenglong Fu⁶, Member, IEEE

Index Terms—Phase variable, speed-adaptation, prostheses.

Firstly, in the letter [1], there is a missing citation in Section II, part B, the first sentence. It should be “In a manner similar to [2], [3], speed estimation was achieved by a double-pendulum model.” In our previous version [1], speed estimation was based on the principles in [3]. We also referred to the interpretation and expression form of 6 and 7 in [2], but did not cite this reference in [1]. It should be noted that the 9 in [1] is not the same as 5 in [2]. Because our prosthesis can measure the kinematic information of the hip, knee, and ankle, we considered using the kinematics of the three joints to estimate the velocity, instead of only using the angle hip and knee as in [2], therefore we additionally introduced the ankle angle in 9 of [1]. This led to changes in the lower extremity model used in our calculations and changes in the formula for calculating the stride length.

Secondly, there is a missing citation in Section II, part A, Section 2), paragraph 2, first sentence. It should be “To address these problems, a dynamic model [4] for the proposed phase variable was constructed, and a Kalman filter was designed to smooth the estimated phase variable.” Although we introduced [4] in the Introduction, we also used a dynamic model similar to 1 and 2 in [4], which we should cite it. It should be noted that our study [1] only use Kalman filter to suppress sensor measurement noise and smooth the phase, which is different from the use of extended Kalman filter and Gaussian process observation model to estimate gait phase in [4]. Because the phase changes linearly, the dynamic model of the phase used for Kalman filter can be only written

Manuscript received 24 August 2022; accepted 24 August 2022. Date of current version 2 September 2022. This letter was recommended for publication by Associate Editor D. Oetomo and Editor P. Valdastri upon evaluation of the reviewers’ comments. (Teng Ma and Yuxuan Wang contributed equally to this work.) (Corresponding authors: Chenglong Fu; Haoyong Yu.)

Teng Ma is with the Shenzhen Key Laboratory of Biomimetic Robotics and Intelligent Systems and Guangdong Provincial Key Laboratory of Human Augmentation and Rehabilitation Robotics in Universities, Department of Mechanical and Energy Engineering, Southern University of Science and Technology, Shenzhen 518055, China, and also with the Department of Biomedical Engineering, National University of Singapore, Singapore 119077 (e-mail: teng.ma@u.nus.edu).

Yuxuan Wang, Xinxing Chen, Chuheng Chen, and Chenglong Fu are with the Shenzhen Key Laboratory of Biomimetic Robotics and Intelligent Systems and Guangdong Provincial Key Laboratory of Human Augmentation and Rehabilitation Robotics in Universities, Department of Mechanical and Energy Engineering, Southern University of Science and Technology, Shenzhen 518055, China (e-mail: 11811119@mail.sustech.edu.cn; chenxx@sustech.edu.cn; 12032418@mail.sustech.edu.cn; fucl@sustech.edu.cn).

Zhimin Hou and Haoyong Yu are with the Department of Biomedical Engineering, National University of Singapore, Singapore 119077 (e-mail: biehz@nus.edu.sg; biehy@nus.edu.sg).

Digital Object Identifier 10.1109/LRA.2022.3201957

as 5 when using the Kalman filter, but this does not mean that we have used the method of [4].

Thirdly, 4 in [1] is similar to 23 in [5]. It should be noted that [1] was submitted on February 24, 2022, while [5] was published in *TechRxiv* on February 22, 2022. The authors in [1] did not read [5] before submission, but considering that the publication date of [5] is two days earlier than the submission date of [1], we should cite [5] in this correction. Besides, in order to prevent the phase from saturating in the third interval in [1], it is straightforward to use a phase rate integral in 4 for increasing the phase linearly. Meanwhile, our study [1] divided the thigh angle into three intervals and used the 4 to calculate the gait phase in the third intervals. [5] divides the gait cycle into five intervals that are different from ours, and uses the 23 to calculate the phase variable in the third and fifth interval.

Although the speed estimation is not the contribution of [1], our interpretation of speed estimation referred to [2]. Based on the missing citations in [1], all the authors express sincere apologies to the authors of [2], [4], [5] and the related editors.

REFERENCES

- [1] T. Ma et al., “A piecewise monotonic smooth phase variable for speed-adaptation control of powered knee-ankle prostheses,” *IEEE Robot. Automat. Lett.*, vol. 7, no. 3, pp. 8526–8533, Jul. 2022.
- [2] T. K. Best, K. R. Embry, E. J. Rouse, and R. D. Gregg, “Phase-variable control of a powered knee-ankle prosthesis over continuously varying speeds and inclines,” in *Proc. IEEE/RSJ Int. Conf. Intell. Robots Syst.*, 2021, pp. 6182–6189.
- [3] K. Aminian, B. Najafi, C. Büla, P.-F. Leyvraz, and P. Robert, “Spatio-temporal parameters of gait measured by an ambulatory system using miniature gyroscopes,” *J. Biomech.*, vol. 35, no. 5, pp. 689–699, 2002.
- [4] N. Thatté, T. Shah, and H. Geyer, “Robust and adaptive lower limb prosthesis stance control via extended Kalman filter-based gait phase estimation,” *IEEE Robot. Autom. Lett.*, vol. 4, no. 4, pp. 3129–3136, Oct. 2019.
- [5] T. Best, C. Welker, E. Rouse, and R. Gregg, “Data-driven variable impedance control of a powered knee-ankle prosthesis for adaptive speed and incline walking,” *TechRxiv*, 2022. [Online]. Available: <https://doi.org/10.36227/techrxiv.19165895.v3>