Static balance control and external force estimation using ground reaction forces

Satoshi ITO[1,2], Yoshihiro AOYAMA[3] and Haruhisa KAWASAKI[4]

[1]Gifu Univ., Fac. of Eng., Yanagido 1-1, Gifu 501-1193, Japan, satoshi@robo.mech.gifu-u.ac.jp

[2]RIKEN, BMC res. cent, Anagahora, Shimo-shidami, Moriyama, Nagoya 463-0003, Japan

[2]Gifu Univ., Fac. of Eng., Yanagido 1-1, Gifu 501-1193, Japan, e3012001@guedu.cc.gifu-u.ac.jp

[3]Gifu Univ., Fac. of Eng., Yanagido 1-1, Gifu 501-1193, Japan, h_kawasa@cc.gifu-u.ac.jp

1. Introduction

Locomotion necessary produces interactions with environments. All the responses of the action to environments, or the changes there, are reflected in the ground reaction forces. Therefore, we consider a balance control with focusing on ground reaction forces in this paper. To keep the analysis simple, the static balance is treated.

2. Control of static balance

Static balance is often controlled by the ankle joint [1]. This behavior is enough described by the model as shown in Fig. 1. In order to include effects from environments, we consider constant external forces as the environmental conditions. The horizontal and vertical components of them are expressed by F_x and F_y, respectively. The model contacts the ground only at the two points, where the vertical component of ground reaction forces F_T and F_H are detectable. The goal of static balance control here is to make F_H and F_T equal at the stationary state with keeping the body part from tumbling. Using the PD control with integral feedback of $F_H - F_T$, The stationary posture such as shown in Fig. 1 emerges [2]. Note that the stationary posture changes adaptively with the external forces. Because the environmental conditions are reflected in the ground reaction forces, the magnitude and direction of the external forces can be estimated from the states of stationary posture. Based on these estimates, a desired posture appropriate to the current environments is internally generated, which is utilized for the behavior at the next trail.

3. Conclusion

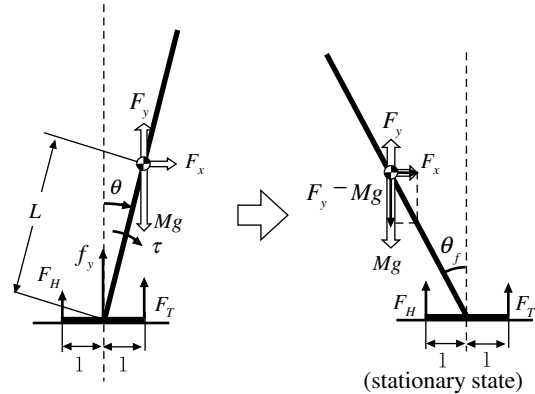The control scheme in this paper is summarized as a block diagram in Fig. 2

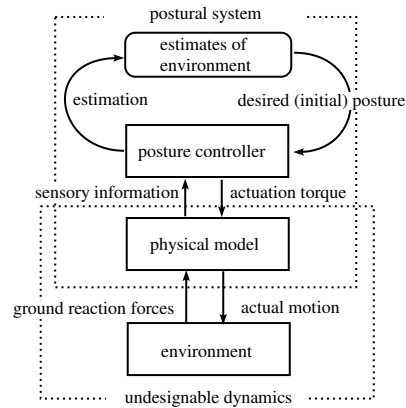Figure 1: Model and stationary posture by proposed control law.

Figure 2: Control scheme.

References

[1] Horak F. B. and Nashner L. M., 1986, *J. Neurophysiol*, 55(6): 1369–1382

[2] Ito. S., Nishigaki T. Kawasaki H, 2001, *Proc. of the ISHF2001*, Sapporo, 515-520 (2001)