Identification of Human Standing Controller based on Robot Controller

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1 Motivation

A mathematical model of a human's behavior contributes to designing human-oriented systems and artifacts such as user interfaces, human-assisting and rehabilitation machines, etc. and to suggest ways of athletic ability evaluations and diagnoses. Too much detailed model of a human body, however, is not necessarily preferable for the above purposes. The relationship between the center of mass and the zero-moment point (COM-ZMP model) presents the macroscopic dynamics, which highlights principal aspects of motor control as Fig. 1. Many controllers based on COM-ZMP model designed for humanoid robots possibly work as models of humans' motor controllers since they stand on the same mathematical principle to coordinate human-formed mechanical systems. The authors report their recent work to identify a human's standing controller based on the above idea with the process and result.

2 Method

Parametric identifications can be conducted if having a model equation and sampled loci. It is required to collect a sufficient number of loci for a trustworthy result. However, since humans unconsciously stabilize themselves, it is not trivial how to see behaviors in a distance from the stable equilibrium point. An idea is to predict typical behaviors in some regions in the phase space based on the model and add preparatory motions to each trial in order to carry the state of COM to adequate initial values using e.g. an assistive platform as illustrated in Fig. 2. Fig. 3 shows snapshots of an example motion measurement. Another problem is that the system to be identified has a piecewise dynamics due to the dynamical constraint on ZMP, so that not only the parameters but also boundaries of segments have to be identified. By performing returning recursive least square (RLS), the trust region can be estimated as Fig. 4. Fig. 5 presents the result.

3 Findings

The identified system fits well to the sampled loci and exhibits a similar structure to the theoretical model, so that the COM-ZMP model and a controller adopted in this work are available as a model of a human standing controller. The identified segment matches with the estimated trust region, which means that the technique of returning RLS partitioned the system consistently. It is known that the distance between two red lines in Fig. 5 and the parallelism of the red lines and the blue lines are related with the responsivity against perturbations and the equilibrium sense, respectively. Hence, the result quantifies those factors of the examinee.

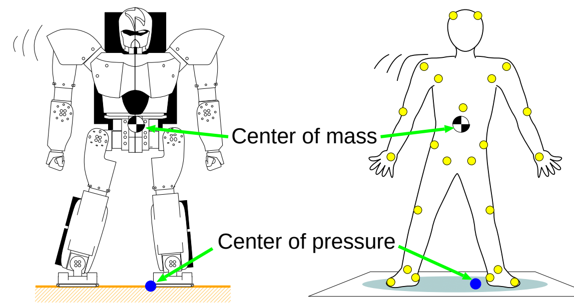

Fig. 1: COM-ZMP model highlights common principle in dynamics of human-formed mechanical systems

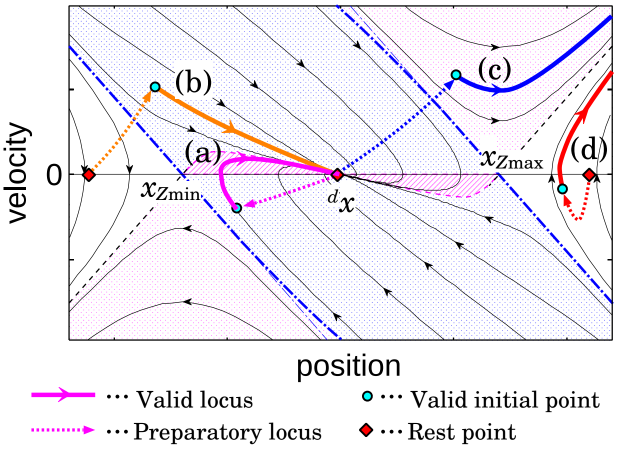

Fig. 2: Loci of behaviors predicted in phase space

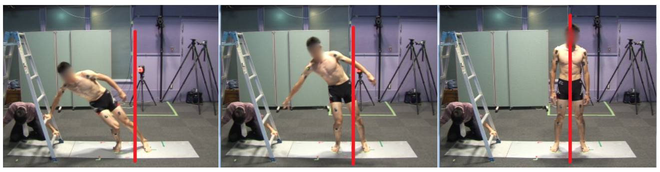

Fig. 3: Snapshots of a motion measurement

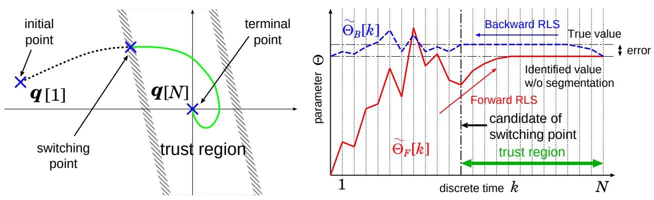

Fig. 4: Identification of trust region and parameters utilizing RLS

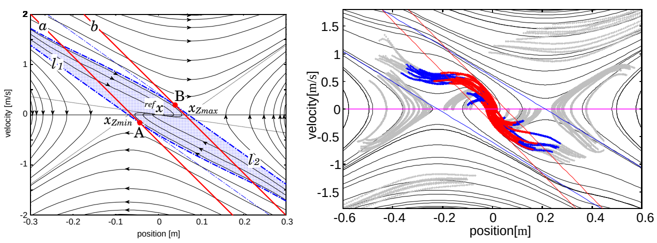

Fig. 5: Theoretical and identified phase portrait

References

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