Pre-defined Ranges of Parameters for Walking Styles on Bipedal Robot with Pelvis-located Actuation

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***Abstract*—The role of pelvis in being a significant contributor to walking is evident from biomechanics [1] and embodied movement analysis [2]. In light of this importance, a biped model has been proposed in past that considers the simplified effect of human pelvis. In the current work, a range of trajectories for this simulated pelvis are being investigated such that they result in feasible gaits. With this formal approach of exploring the gaits, it will be easier to classify different walking styles for this biped model.**

I. Introduction

In embodied movement analysis, emphasis has been laid on the movement of pelvis for human walking. In particular, Irmgard Bartenieff [2] specifies Forward Pelvic Shift and Lateral Pelvic Shift to be important contributors in walking. These findings are also inline with the seminal work in biomechanics of walking [1] in which role of pelvic movements is highlighted. Inspired from this understanding of human walking, a robot design is proposed that incorporates actuation located at pelvis.

A planar model simplification of the bipedal robot is presented [3] in Fig. 1 which has a piston mechanism moving a heavy mass forward and backward using a force actuator. The open-loop control for this model is derived from a feasibility problem formulation [3] using trajectory optimization tool GPOPS-II [4]. The optimization routine looks for control inputs and state trajectories that satisfy desired displacement PS of pelvis mass M_t, the step length given by TL, among other constraints.

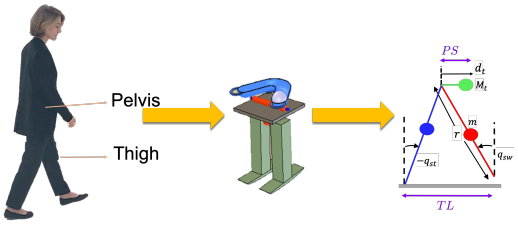

Fig. 1: Human inspiration in developing a bipedal robot with pelvis-located actuation.

II. Trajectories for Simulated Pevlis

The desired trajectory PS can be formulated as a Fourier Series expansion:

$$PS(t) = a_0 + \sum_{i=1}^{\infty}(a_i^2 + b_i^2),$$

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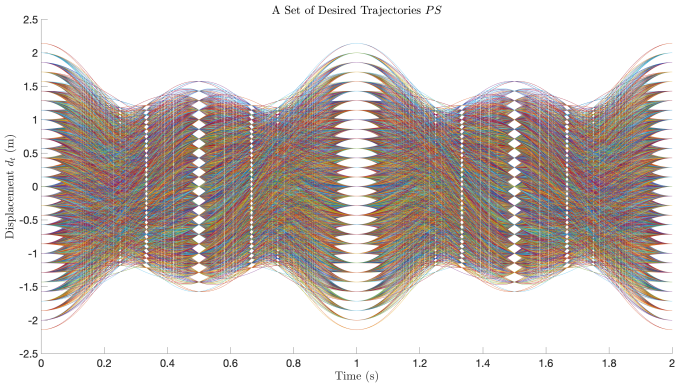

Fig. 2: A set of PS trajectories by sweeping Fourier coefficients over the range $[-1, 1]^5$ for the five coefficients.

where $a_0 \in \mathbb{R}, a_n \in \mathbb{R}^2$, and $b_n \in \mathbb{R}^2$. Instead of choosing hand-picked trajectories for PS, this formulation is a more systematic way of choosing desired waveform of the pelvis mass. By parameter sweep over a defined range (an example in Fig. 2), capabilities of this model (e.g. total number of possible gait styles etc.) can be investigated more formally.

The work proposed here is on systematically generating walking styles that are validated from humans in the next stage. In this regard, a feasibility problem formulation is fed with desired trajectory for the simulated pelvis and in turn feasible gaits (if existing) are generated. Using Fourier series with co-efficients over a defined range, it is easier to investigate (and later classify) how many gait styles can be generated for this model.

References

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