A Hybrid ZMP-CPG Based Walk Engine for Biped Robots

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Abstract. Developing an optimized omni-directional walking for biped robots is a challenging task due to their complex dynamics and kinematics. We propose a hierarchical walk engine structure to generate a fast and stable omni-directional walk, with push recovery strategies. This fully parametric structure allowed us to optimize the robot walk, achieving a speed increase of 18%.

1 Problem Statement

We are aiming to to develop a humanoid robot's walk engine that has human-like motions, allows for omni-directional movement, and has push-recovery capabilities. This walk engine can be easily and efficiently optimized using machine learning in order to achieve its fastest speed.

2 Proposal

We propose a hierarchical structure to generate an omni-directional walk engine [1]. This structure decouples the walking motion into three hierarchy levels to increase flexibility and portability. In the first level, *Three-Dimensional Linear Inverted Pendulum* and *Partial Fourier Series* oscillators are used to generate the trajectory of the feet. In the second level, two human-inspired push recovery strategies are developed to increase stability during walking. The third level contains all the modules which depend on the robot's platform, which leads to a highly portable walk engine. We used CREPS-CMA to find the optimal walking parameters, and experimental results showed an increase of 18% speed (59 cm/s) against our best hand-tuned solution. We achieved a fast and stable omni-directional walk, capable of recovering from pushes and unexpected obstacles. In the future, we intend to develop a knee push recovery strategy as well.

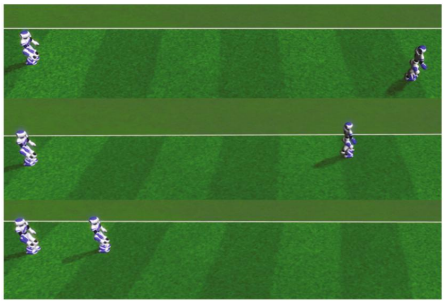

Figure 1. Distance traveled in a fixed amount of time. From top to bottom, the optimized speed, the fastest hand-tuned speed, and the slow and stable hand-tuned speed.

References

1. Kasaei, S.M., Simoes, D., Lau, N., Pereira, A.: A hybrid zmp-cpg based walk engine for biped robots. In: Ollero, A., Sanfeliu, A., Montano, L., Lau, N., Cardeira, C. (eds.) ROBOT 2017: Third Iberian Robotics Conference. pp. 743–755. Springer International Publishing (2018)