The Translation of In-Air Movement to On-Ground Locomotion of a Tendon-Driven Quadruped Through Adaptive Learning

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Abstract

The ability to take a known skill and adapt it to a novel task is fundamental to lifelong learning(Kudithipudi et al., 2022). Here we show in hardware that the knowledge a quadruped gains by babbling and refining movement in-air is beneficial to further learning when transitioning from movement in-air to on-ground(Marjaninejad, Urbina-Meléndez, et al., 2019b; Marjaninejad, 2021). The quadruped creates an implicit model of its own kinematics by undergoing five minutes of motor babbling and training an artificial neural network (ANN) to produce the inverse kinematics through usage of the General-to-Particular (G2P) autonomous learning algorithm(Marjaninejad, Urbina-Meléndez, et al., 2019a; Sun et al., 2019). By feeding a set of desired kinematics into this ANN we produce a set of motor activations that the model predicts will result in those kinematics; the error between desired and actual kinematics obtained from the activations can then be used to refine the model with a few-shot learning approach.

The robot went through eight refinements of in-air movement and was then placed in contact with the ground to continue training. Because the quadruped is first trained in air, the model predicted lower muscle activations than the ones really needed to overcome contact with the ground. To counteract this, a velocity compensation term based on the positional and cumulative error of each trial is added to the desired kinematics(Marjaninejad, Urbina-Meléndez, et al., 2019b) resulting in an increased muscle activation at points of previously too low activation and decreased muscle activation at points of previously too high activation. Critically, this velocity compensation term is used as the connecting link between the quadruped's knowledge of in-air movements and the final explorations to complete the translation to on-ground locomotion.

The current results of this study show the usefulness of transferring learned in-air movements to on-ground locomotion(Kudithipudi et al., 2022), but also highlight the need for systems to be able to adapt as they learn in order to transfer learned skills to novel situations(Marjaninejad, Urbina-Meléndez, et al., 2019b).

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