Conversion of a Quadruped to Low-Cost, Multi-Arm Manipulator

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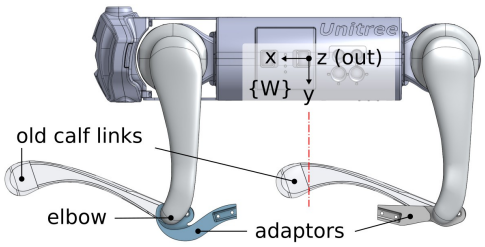


Figure 1: A top view of the Go1 manipulator. The calf links are replaced by extensible adaptors. The symmetry plane of the new workspace is shown in red.

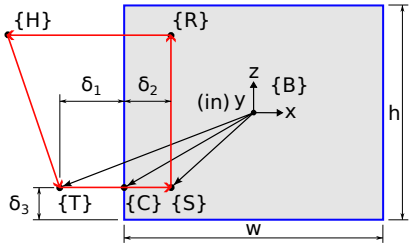


Figure 2: The left arm trajectory of the box flipping skill (red) in relation to the box geometry (blue). The trajectory starts and ends at point H. The right arm trajectory is a reflection and is executed simultaneously.

1 Introduction

Many robotic applications require both dynamic and safe manipulation systems. Commercially available industrial and collaborative arms only satisfy one requirement simultaneously due to the tradeoff between high inertia, mass, speed, and impact energy. Some bimanual systems have been designed with fast, low inertia, and lightweight arms [1], but these remain unavailable to the global research community. Alternatively, quadruped legs possess similar mechanical characteristics [2] and have shown potential for dextrous manipulation [3]. Thus, we present two contributions; a process which converts a Unitree Go1 quadruped into a dynamic, collaborative, low cost, four arm manipulation system, and the implementation of a kinematic box flipping application with the aforementioned hardware.

2 Conversion Process and Box Flipping Skill Design

The Unitree Go1 EDU is a widely available quadruped platform costing less than €10,000. The legs are three-DOF, and are controlled through a joint position, velocity, and current control interface, suitable for manipulation applications where low level force control is required. The mechanical conversion process replaces the distal calf links with adaptors with offset joint angles, allowing an "elbows out" workspace with symmetric arms about the transverse plane. The adaptors contain a tapered slot, which is an extensible interface for rapid swapping of end effectors. The adaptors interface with the existing power transmission components, meaning no modifications to the SDK are required for control. Overall, the conversion process is fully reversible, and requires no exotic tools or parts.

Using the converted hardware, we implement a non-prehensile manipulation skill flipping a box by 90 degrees. The skill is implemented kinematically, and the trajectory is computed from the box pose and geometry, as shown in figure 2. The skill tuning is done with the delta parameters and controller gains. Particularly, δ_2 and the proportional controller gain K_p determine the amount of grasping force generated between the colinear, antipodal contact points C, since the setpoints S and R lie inside the box geometry. A successful demonstration of the skill is available here: https://youtu.be/9vyEhdY2h0E.

3 Conclusion and Future Work

In this work, we demonstrate a kinematic box flipping skill with a low cost, low inertia, high speed manipulator, obtained by adapting a Go1 quadruped robot. We are currently improving the software architecture to allow for realtime swapping of controllers at the instance of contact. We plan to use this platform for placement of heavy, large objects in collaboration with underactuated lift assist mechanisms.

References

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