Design and Control of an Open-Source Agile Bipedal Humanoid Robot with High-Torque Density Motors for Household Assistance

Danyi Chen, Matei Dan, Varun Shetty, Thomas H. Taylor, Weibo Gao, Israel Dominguez, Shipali Ranjan, and Hao Su*, *IEEE Senior Member*

With the aging population in the US on the rise [1], there is a pressing need for care for the elderly, particularly those aged 65 and above. The existing elderly care system primarily relies on nursing home service workers. However, given the demographic shift in recent years, alternative solutions are required. Humanoid service robots can be a potential solution to this problem. These robots can access community settings and perform many of the tasks that human caregivers do. Unfortunately, the complexity of humanoid systems limits accessibility to most institutions. The current state-of-the-art humanoid robots still use low-bandwidth conventional hydraulic actuators, have limited manipulation capabilities, and require time-consuming programming in the form of model predictive control, as shown in Fig. 1.

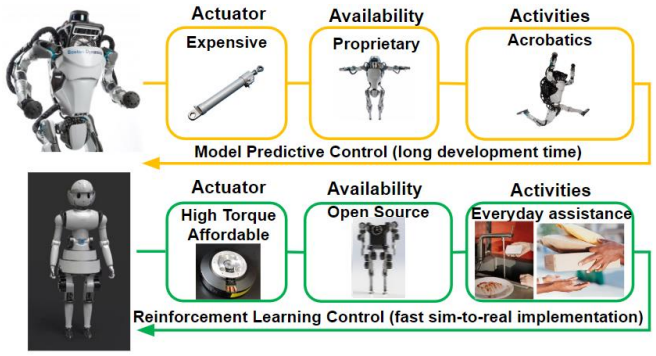

Fig. 1 Comparing the conventional humanoid robot design paradigm with the proposed design. State-of-the-art humanoid robots are often equipped with hydraulic actuators, which are prone to failure, costly, and have limited bandwidth. In contrast, the proposed design will implement quasi-direct drive actuators, which are characterized by affordability and high bandwidth, allowing for better control [2]. Model-free reinforcement learning will eliminate the need for accurate modeling of home service scenarios which is difficult and time-consuming. Moreover, the novel robot design will distinguish itself from its counterparts by incorporating intelligent computer vision and path planning capabilities.

To bridge this gap, we propose an open-source bipedal humanoid robot design that employs actuators based on the novel quasi-direct-drive paradigm [3], time-efficient model-free reinforcement learning control strategies [4], and intelligent computer vision-based navigation planning. Our goal is to develop an accessible mechanical and software platform that can provide institutions with an opportunity to engage in the emerging field of humanoid robotics for household care.

Fig. 2 depicts the proposed blueprint of an open-source bipedal humanoid robot, which features a lower limb configuration consisting of five degrees of freedom per leg and an upper limb design comprising four degrees of freedom per arm. The joint mechanisms of this robot are exclusively powered by high-torque quasi-direct-drive actuators. The proposed robot's dimensions are such that it reaches a height of approximately 1.2 meters when fully extended and exhibits anthropometric proportions that are comparable to those of a human being.

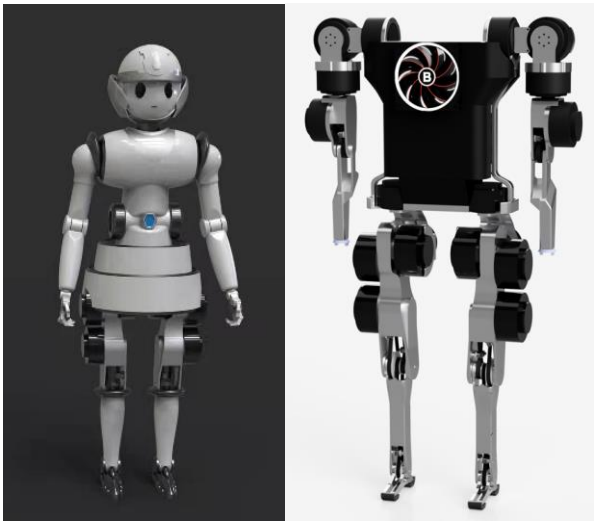

Fig. 2 Computer renderings of the proposed bipedal humanoid robot. Initial concept rendering of a child-sized assistance robot (left). CAD design of the proposed humanoid robot (right). These visual materials aim to provide a preliminary glimpse of the envisioned robot design.

All authors are with the Laboratory of Biomechatronics and Intelligent Robotics, Department of Mechanical and Aerospace Engineering, North Carolina State University, Raleigh, NC 27695 USA. and Joint NCSU/UNC Department of Biomedical Engineering, North Carolina State University, Raleigh, NC, 27695; University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA.

*Corresponding author. Email: hao.su796@ncsu.edu

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