

Design and Evaluation of a Novel, Lightweight, 2 Degree of Freedom Parallel Jaw Gripper with 2-Speed Gearboxes

Pranjal Khakse[†], Revanth Damerla^{†*}, *Student Member, IEEE*, Aamod Gandhi, Qizhang Shen, Adhit Ranjan, and Shorya Awtar, *Member, IEEE*

Abstract: This paper presents the design and evaluation of a novel, lightweight, 2 Degree of Freedom (DoF) parallel jaw gripper that incorporates compact active two-speed gearboxes. The gripper architecture combines frameless BLDC motors, a planetary two-speed gearbox with a solenoid-actuated clutch, and lead screws to achieve a balance of high grasp force, fast actuation, and low weight. Unlike existing active multi-speed transmissions that rely on multiple heavy actuators, our approach uses a single primary motor with a lightweight clutch, enabling substantial weight reduction. The resulting prototype weighs only 269 g—approximately one-third of comparable commercial grippers such as the Robotiq 2F-85—while achieving a maximum stroke of 85 mm, grasp forces up to 167.8 N, and closing speeds of 102 mm/s. Although manufacturing imperfections in the lead screws limited peak output force below the theoretical maximum of 235 N, the gripper achieves the highest specific force among analyzed designs and demonstrates reliable grasping across a diverse set of objects. The proposed two-speed gearbox gripper highlights a promising pathway toward compact, energy-efficient end effectors that extend the operational life of mobile and collaborative robots, with future work focused on optimizing screw efficiency, clutch weight, and jaw surface compliance.

This research was supported by the Michigan Economic Development Corporation and the University of Michigan through a Michigan Translational Research and Commercialization (MTRAC) grant (Case-392295; Lansing, MI) and the UM Engineering Translational Research (ETR) Fund. Pranjal Khakse was supported by a UM Rackham Graduate Student Research Grant during this research.

[†]Pranjal Khakse and Revanth Damerla contributed equally to this work.

^{*}Revanth Damerla is Corresponding Author: damerla@umich.edu

All authors are with the Precision Systems Design Laboratory, Department of Mechanical Engineering, University of Michigan at Ann Arbor, Ann Arbor, MI 48109 USA.