Design and experimental testing of a load cell-integrated active suspension system for terrain-adaptive mobile robots

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Instability and reduced adaptability are often encountered by mobile robots when operating on rough terrain. To address this, a passive suspension system is converted into an active suspension system. A cost-effective prototype has been developed and experimentally validated to demonstrate improved stability and mobility. This paper presents a quarter-car model of an active suspension system that uses a motor-driven linear actuator and load cell to provide real-time force feedback to a PID control algorithm, which controls the linear actuator to maintain chassis stability. The mechanical parts were 3D printed to develop a linear actuator with a lead screw, enabling accurate vertical movement. The process variable was the load cell's feedback, whereby the actuator response was dynamically adjusted to provide a stable chassis orientation under changing load and terrain conditions. The system operates at a variety of angles and speeds, with optimal stability observed at 0.0667 m/s on incline angles and 0.0167 m/s on decline angles, reducing chassis angular deviations to ±1.2°. The results showed that the load cell–integrated linear actuator strut assembly improves suspension adaptability while maintaining quarter-car model stability, demonstrating a cost-effective approach that could enhance mobile robots' robustness for applications in autonomous vehicles, agriculture, and exploration.

Keywords: *Active suspension, Mobile robot, PID control, Terrain adaptability, Load cell*