

# Mobility and Transport

**Tactile Sensor Integration in Ergonomic Wheelchair Pushrims**, N. Zaghi, J. Borisoff, D.W John.  
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**Purpose** Worldwide, more than 65 million people use wheelchairs, and in Canada nearly 200,000 rely on manual wheelchairs (MWCs) [1]. MWC users push their pushrims thousands of times per day, making propulsion efficiency a critical factor in preventing pain, fatigue, and upper-extremity overuse injuries [2]. This is even more prevalent in older adults, often accelerating functional decline, reducing independence and increasing reliance on assistance from others for mobility [3]. To improve grip and propulsion efficiency, some users adopt coated or ergonomic pushrims or transition to power-assist devices. However, existing pushrim-activated power-assist wheels are often bulky and heavily instrumented [4]. We are researching and developing sensed ergonomic pushrims, which combine a soft, high-grip surface with real-time force sensing, offering an intuitive control surface for power-assist devices. This study presents the development and characterization of a sensed elastomeric pushrim designed to capture propulsion mechanics, improve user comfort, and enable an intuitive control interface for power-assist devices that may better support aging wheelchair users. **Method** The sensed pushrim was created by embedding a flexible array of capacitive sensing elements within a continuous elastomeric material molded around a standard pushrim. Each sensor element measures both shear and normal forces, enabling detection of tangential forces associated with propulsion, and radial forces related to grip and stabilization, factors that can change with age, strength, and dexterity [5]. The full circumference sensing system was validated against a reference load cell using a custom jig and stage assembly. Mechanical characterization included controlled shear loading up to 30 N and normal loading up to 50 N to evaluate linearity, hysteresis, and usable force range. This approach enables detailed mapping of the force profile across the entire push phase and allows identification of localized propulsion mechanics and the user's intentions. **Results and Discussion** Characterization showed proportional, repeatable responses across the tested loading ranges, with strong agreement relative to the reference load cell. Shear sensing accurately captured forces up to 27 N, with expected elastomeric creep and relaxation as seen in Figure 1. In simulated propulsion testing, the sensed pushrim successfully differentiated forward and backward pushes based on shear direction and magnitude. The distributed sensor array clearly captured variations in force onset, duration, and decay throughout the propulsion cycle, showing promise in detecting intention to support efficient mobility in older adults. The sensed ergonomic pushrim shows strong potential as a solution for enhancing manual wheelchair propulsion, supporting upper-limb health, and enabling more intuitive power-assist control, particularly for older adults with age-related declines in upper-arm strength who still seek independent mobility. By reliably measuring shear and normal forces around the full circumference, the system provides detailed, user-specific insights into propulsion technique, detecting inefficient or high-risk patterns that could contribute to fatigue or long-term musculoskeletal injury in aging users, while also being an intuitive control surface for power-assist devices.

## References

1. F. Routhier *et al*, "Clinicians' and Researchers' Perspectives on Manual Wheelchair Data Loggers," *Archives of Physical Medicine and Rehabilitation*, vol. 98, (7), pp. 1480-1489, 2017.
2. A. M. Koontz, Y. Yang, D. S. Boninger, J. Kanaly, R. A. Cooper, M. L. Boninger, and L. Ewer, "Investigation of the Performance of an Ergonomic Handrim as a Pain-Relieving Intervention for Manual Wheelchair Users," *Assistive Technology*, vol. 18, no. 2, pp. 123-145, 2006, doi: 10.1080/10400435.2006.10131912.
3. P. S. Requejo, J. Furumasu and S. J. Mulroy, "Evidence-Based Strategies for Preserving Mobility for Elderly and Aging Manual Wheelchair Users," *Topics in Geriatric Rehabilitation*, vol. 31, (1), pp. 26-41, 2015.
4. R. A. Cooper *et al*, "Performance assessment of a pushrim-activated power-assisted wheelchair control system," *IEEE Transactions on Control Systems Technology*, vol. 10, (1), pp. 121-126, 2002
5. K. Morton, R. Ishizaki, Z. Chen, M. S. Sarwar and J. D. W. Madden, "Soft Three-Axis Capacitive Force Sensor for Robotic E-Skin on Curved Surfaces," *IEEE Sensors Letters*, vol. 7, no. 10, pp. 1-4, 2023.

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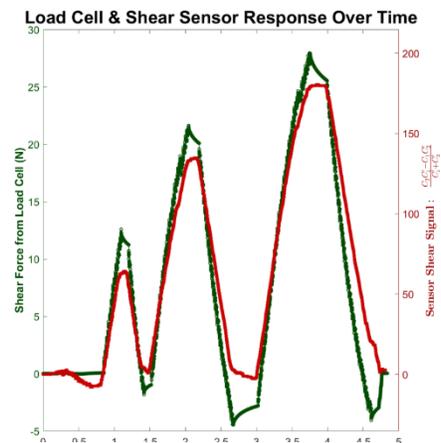


Figure SEQ Figure 1\* ARABIC 1  
Extracted shear signal vs. load cell  
shear measured