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EVALUATING THE EFFECTIVENESS OF BOUNDARY DETECTION SYSTEM(BDS) FOR INDOOR WHEELCHAIR TRAINING

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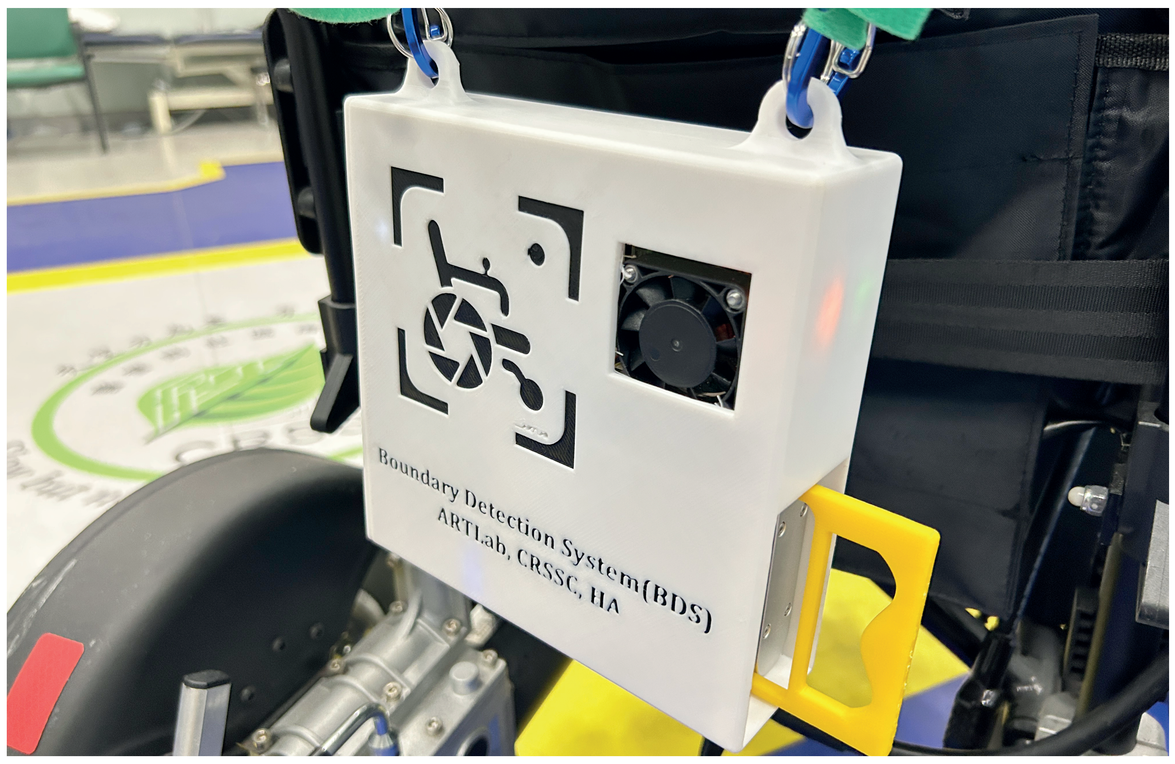
INTRODUCTION & AIM



Powered wheelchair maneuvering skill is essential for independence and safety in people with mobility impairment. However, real-time monitoring of maneuver compliance, in terms of boundary crossing, under training or assessment is challenging for therapists, affecting intervention effectiveness and assessment objectiveness. Current monitoring methods are often limited by coverage, complicated setup, inadvertence or lack of accuracy and detail. To overcome this, rehabilitation engineer at the Hospital Authority Community Rehabilitation Service Support Centre (CRSSC) created an innovative Boundary Detection System (BDS). The study here assesses the effectiveness of the BDS in recording boundary-crossing events, compares 4-camera setups and manual counting, so as to profile users' performance to guide clinical practice.

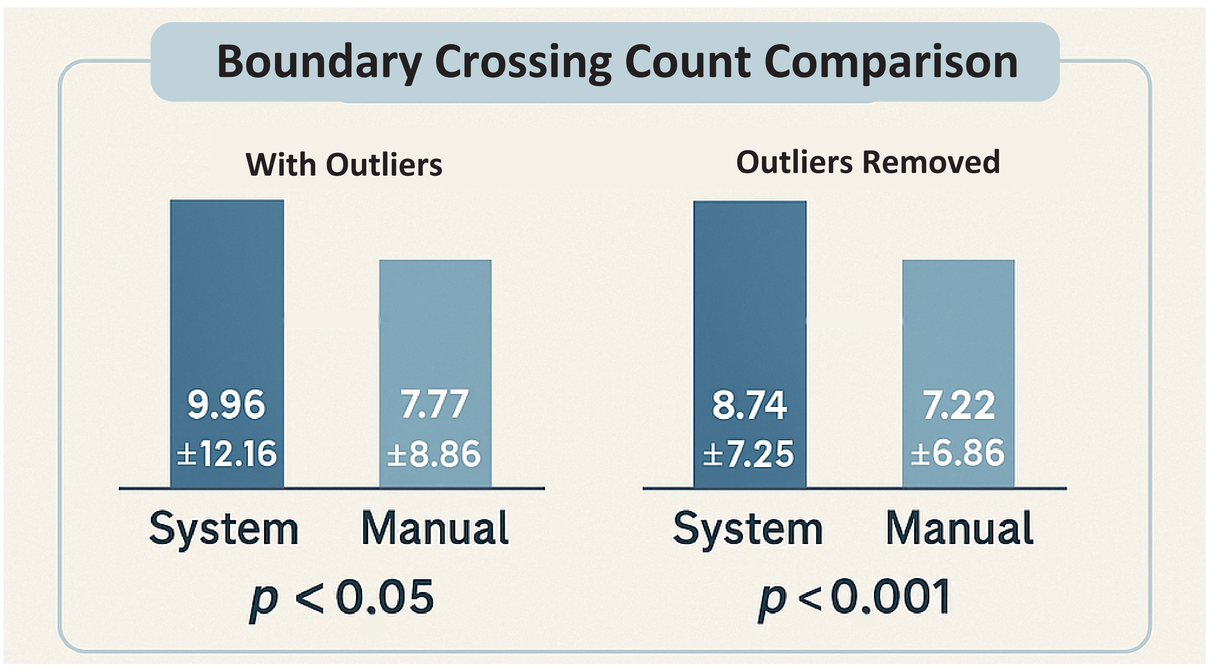
METHOD

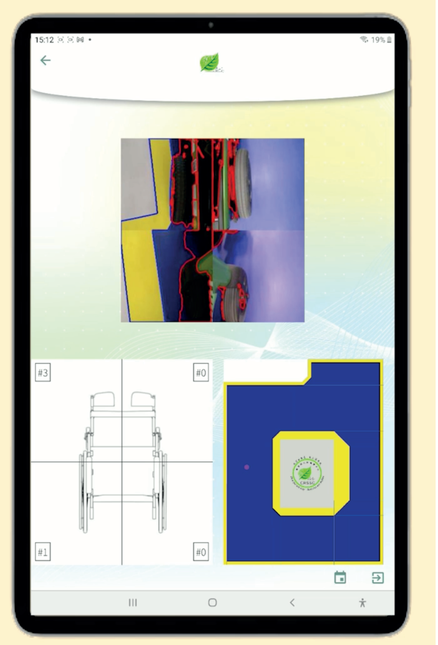
BDS utilized wheelchair-clamped webcams recording real-time video of wheels and boundaries. Through computer vision algorithms, wheels (grey) and boundaries (yellow) were separated through color filtering, with contours identified using binary masking. Boundary violations were registered when wheel contours intersected a dilated boundary contour during indoor training within a “Confined Space Maneuver”. This integrated training environment replicates Hong Kong public housing dimensions and incorporates local powered wheelchair training content, ensuring that proficiency within the circuit equips users to navigate public spaces safely in Hong Kong.

This a prospective study recruited 26 adults via CRSSC outpatient services, the human ethics approvals were acquired from Central Institutional Review Board (Ref. No. KC/KE-23-0216/ER-1). Written informed consent was obtained from all participants before the program started. Subjects were asked to completed clockwise and counterclockwise for 3 laps without cues, throughout sessions, boundary crossing profile record by BDS streamed into a cloud spreadsheet while therapists simultaneously recorded boundary crossings manually.

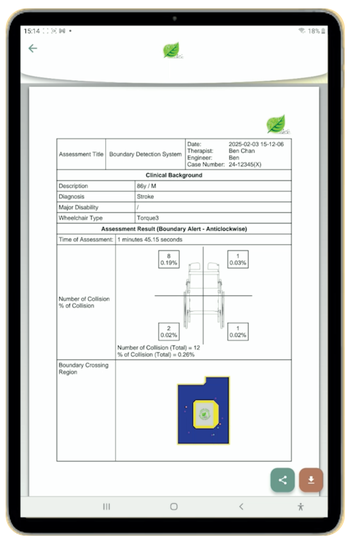
RESULTS & DISCUSSION

13 males and 13 females (mean age = 67.3±10.2) wheelchair user were recruited, 3 were removed because of outliers (with boundary crossing count > 30) afterward. By performing paired t-test on both counting methods. It can be found that the boundary crossing detected by system(9.96 ± 12.16) is significantly greater ($p < 0.05$) than that of manual counting(7.77 ± 8.86). After removal of the outliers, the system-detected boundary crossing (8.74 ± 7.25) differs more significantly ($p < 0.001$) from manual counting method (7.22 ± 6.86). Representing the high sensitivity of the proposed system. Overall, an average of 2.64 ± 2.48 times (0.397 ± 0.327%) of boundary crossing that lasted less than 0.5 second were captured by the system, which shows that the system is more sensitive to boundary crossing event that a human examiner might not even notice, and showcased the system’s ability to eliminate human observation error.





CONCLUSION



This pilot study illustrates the viability of the BDS as a computer vision-based, scalable solution for objective wheelchair training monitoring. Through the quantification of boundary-crossing frequency, profiles, and added value on accuracy, the system provides therapists with objective data to progress monitoring and further tailor interventions. Future research will advance algorithmic accuracy and investigate integrations with clinical rehabilitation practice to modernize intervention effectiveness and objectiveness.