Development of an automated fall detection device specific to wheelchair users

L. A. Rice, L. Abou, A. Fliflet, P. Presti, J. J. Sosnoff, H. P. Mahajan, M. L. Frechette

Purpose Falls are a major health concern among the 65 millions individuals who use a wheelchair worldwide.1 Older adults are four times more likely to use wheelchairs.2 More than 60% of wheelchair users are affected by falls.3 After a fall, wheelchair users spend an average of 9 minutes (range 1-45 min) on the floor and 80% require assistance to recover.4,5 Remaining on the ground for an extended period of time after a fall is associated with a risk of future injurious falls, long term care admissions, and death.6 Automated fall detection devices can be useful to provide timely assistance and minimize the consequences of a long lie.7 Although used widely in ambulatory populations, the ability to detect falls among wheelchair users is limited. Abou, et al8 examined the efficacy of a native fall detection app built into an Apple watch. The device was only able to detected 4.7% of falls from a wheelchair. The development of a fall detection device specific to wheelchair users is needed to facilitate a quick and accurate response after a fall. This presentation will describe the initial development of a fall detection algorithm and device preferences of older adult wheelchair users (target population). **Method** Ethical approval obtained. The algorithm was developed based on repeated falls from a wheelchair with 30 participants. Research-grade accelerometers were attached to the participants' wrist, chest and head. Participants were first asked to performed a series of activities of daily living (e.g. transfers) to train the algorithm on the common, non-fall activities. Next, participants were asked to fall from a manual wheelchair in four directions: forward, left sideways, right sideways and backwards onto a pad. Three fall trials were performed in each direction (12 falls total). For each trial, data were synchronized on the start impulse and divided into 4s sample windows. A 4s data window centered on the fall event or the non-fall data was created in each trial. 38 features were generated for each 4s trial window based on standard protocols.9 Once the features were generated and selected, a feature vector was formed. Features were then normalized in the range between fall and non-fall classes. During classification, feature vectors extracted from the data were fed into the model, which recognizes the activity (non-fall or fall) of the user. An SVM technique with a K-Fold Cross Validation training classifier was used to avoid overfitting.9 Feedback on the physical specifications of a fall detection device was obtain from interviews with the target population. **Results and Discussion** Accelerometers mounted at the chest and wrist presented with the best prediction outcomes to detect falls from a wheelchair, accuracy = 99.5% and 99.6%, respectively. Fifteen older adults who use wheelchairs reported they preferred a fall detection device to be in watch form. Participants wanted the ability to modify who is contacted in the event of a fall and to cancel a notification of fall in the event of a false alarm. Further testing will be performed to examine accuracy in a community setting.

References

World Health Organization. *World Report on Disability 2011*. 2011. http://www.who.int/disabilities/world_report/2011/en/

Clarke P, Colantonio A. Wheelchair Use Among Community-Dwelling Older Adults: Prevalence and Risk Factors in a National Sample. *Canadian Journal on Aging / La Revue canadienne du vieillissement*. 2005-01-01 2005;24(2):191-198. https://doi.org/10.1353/cja.2005.0059

Kirby RL, Ackroyd-Stolarz SA, Brown MG, Kirkland SA, MacLeod DA. Wheelchair-related accidents caused by tips and falls among noninstitutionalized users of manually propelled wheelchairs in Nova Scotia. *Am J Phys Med Rehabil*. 1994 Sep-Oct 1994;73(5):319-30.

Rice LA, Sung J, Peters J, Bartlo WD, Sosnoff JJ. Perceptions of fall circumstances, injuries and recovery techniques among power wheelchair users: a qualitative study. *Clin Rehabil*. Apr 2018:269215518768385. https://doi.org/10.1177/0269215518768385

Rice LA, Peters J, Sung J, Bartlo WD, Sosnoff JJ. Perceptions of Fall Circumstances, Recovery Methods, and Community Participation in Manual Wheelchair Users. *Am J Phys Med Rehabil*. Aug 2019;98(8):649-656. https://doi.org/10.1097/PHM.0000000000001161

Tischler L, Hobson S. Fear of Falling: A Qualitative Study Among Community-Dwelling Older Adults. *Physical & Occupational Therapy In Geriatrics*. 2005/01/01 2005;23(4):37-53. https://doi.org/10.1080/J148v23n04_03

Fleming J, Brayne C. Inability to get up after falling, subsequent time on floor, and summoning help: prospective cohort study in people over 90. *Bmj*. Nov 17 2008;337:a2227. https://doi.org/10.1136/bmj.a2227

Abou L, Fliflet A, Hawari L, et al. Sensitivity of Apple Watch fall detection feature among wheelchair users. *Assistive Technology*. 2021-05-25 2021:1-7. https://doi.org/10.1080/10400435.2021.1923087

Vallabh P, Malekian R, Ye N, Bogatinoska DC. Fall detection using machine learning algorithms. 2016:1-9.

Keywords: accidental falls, wheelchair, older adult, fall detection

Address: University of Illinois Urbana-Champaign, USA
Email: ricela@illinois.edu