ACHIEVING AFFORDABLE QUANTITATIVE ASSESSMENT OF DAILY PRESSURE RELIEF ACTIVITIES FOR MANUAL WHEELCHAIR USERS

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Background: There are over 1.5 million manual wheelchair users (MWUs) in the U.S. Due to their sensory or mobility impairments, MWUs are vulnerable to pressure ulcers (PUs), which can significantly affect their quality of life. To reduce PU risks, Clinical Practice Guidelines (CPGs) recommend that MWUs perform daily repositioning activities, i.e., vertical pushups, lateral and forward leans, every 15 to 30 minutes. Despite the effectiveness of these pressure relief activities, the majority of MWUs do not adhere to CPGs. Unfortunately, existing pressure monitoring systems are either designed for clinical use or subject to reliability constraints, making them difficult to become an integral part of MWUs' daily life.
Purpose: To develop and validate a novel approach using machine learning techniques that can distinguish purposeful repositioning activities for pressure relief from non-purposeful daily routine activities in both controlled and natural environments.
Methods: Instead of directly analyzing raw data from accelerometers, we will first transform raw data into its derivative form (i.e., from acceleration into jerk). Then, statistical algorithms will be applied to remove outliers caused by the derivative operation. We will employ state-of-the-art deep learning techniques to construct the recurrent neural network (RNN) so that it can accurately recognize a MWU's pressure relief activities. We will recruit 5 MWUs and 10 healthy volunteers to participate in the controlled study, which will be performed in the Technology for Occupational Performance (TOP) lab at the University of Oklahoma Health Sciences Center (OUHSC). Our physical therapist (PT) will instruct participants to perform repositioning activities according to CPGs every 15 minutes within a 2-hour study period. We will use 70% of the collected data to train our RNN and use the remaining 30% to validate whether the RNN can correctly distinguish the purposeful repositioning activities from the non-purposeful counterparts. Next, we will recruit another 5 MWUs to validate the proposed MCC system in their natural environments. We will have a PT accompany a research participant during the daytime for 6 to 8 hours in his/her natural environment. Whenever a participant performs a pressure relief activity, the PT will record its type, start time, and duration.
Results: As our proposed approach is designed to identify and utilize deep learning for the intrinsic patterns associated with hand movements, the accuracy for recognizing purposeful repositioning activities should be high with little variance in both controlled and MWUs' natural environments (e.g., office, home, community, etc.). The controller study will validate the study protocol as well as provide training data for the RNN machine learning algorithm.
Conclusion: Our proposed approach is nonintrusive and does not rely on expensive devices. A MWU will simply wear a smartwatch (which can cost less than $100) to collect hand activity data. Our proposed approach will provide quantitative evaluations regarding the frequency and durations of pressure relief activities so that both healthcare providers and MWUs can assess whether the CPGs are followed. Since no practical pressure monitoring systems are currently available for MWUs, our proposed approach will be promising to fill the vacancy.
Relevance to Allied Health: This topic is relevant to many allied health professions due to the fact that compliance to rehabilitation interventions is critical for the success of the treatment. The proposed techniques have potential to increase the adherence to clinical practice guidelines. With proposed results achieved, coupled with the mobile and cloud settings, healthcare providers will be able to remotely monitor MWUs' pressure relief activities to provide effective interventions. The approach can also be adapted to other professions and patient populations.