Characterisation of accelerometer on an ambulatory patient monitoring device for fall detection

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Summary

This paper reports on the results of research undertaken to develop a wearable ambulatory fall detector with integrated vitalsigns by implementing a novel algorithm onto a newly CE approved wireless vitalsigns monitor. An ambulatory monitor that alarms on fall events is of clear benefit to the elderly, infirm or those living independently; to enhance their health, sense of safety and wellness. Results show that during laboratory testing, movements categorised as 'activities of daily living' (ADL) were detected with around 90% accuracy and falls detected with 100% accuracy, with all data being independently verified using 2 alternative technologies.

Detail

For today's aging society, falls are the leading cause of injury-related deaths and hospitalisation among the elderly. The faller may often remain on the ground for a considerable amount of time, which occurs in some 20% of hospital admissions. The ability to detect and report falls to a caregiver would result in direct reduction of the 'long lie' scenario. To address this need a recently CE approved wireless ambulatory patient vitalsigns monitor, which records ECG, temperature and 3- axial accelerometer data (±6g), has been modified to detect a variety of user movements. In the device's current form it records accelerometer data and makes it available to clinicians to corroborate specific cardiac events which traditionally exhibit increased patient movement (e.g. hypoglycemia). It has not however been accurately calibrated to detect and distinguish specific user movements, including trips and falls.

Using a novel algorithm (based on thresholding of resultant accelerations), the processed accelerometer data has been proven to determine real-time user activity, including standing, walking, climbing stairs, posture and various types of falling. Three different types of fall were investigated; forward falls, backward falls and sideward falls to both sides (simulated onto crash mats). During laboratory testing, specific user ADL were detected with around 90% accuracy, and falls detected with 100% accuracy. The less than perfect detections for ADL occurred due to occasional issues deciphering between walking/stair walking, as both generate similar accelerometer signals. Additionally, some researchers report problems with the sitting down activity being mistaken for a backwards fall. This new algorithm suitably distinguishes between these two events without compromise.

To ensure authenticity of the data recorded, accelerometer data from a Shimmer device was recorded and processed simultaneously to validate results, as well as data captured from a specialist high speed video camera to reconstruct the movements on the computer afterwards, using motion analysis software to scrutinise velocity, acceleration and inertia of each test. Sizable datasets also confirm that results are repeatable.

In conclusion, this work presents results of the implementation of a novel algorithm for fall detection on an ambulatory vitalsigns patient monitor and has been proven to detect fall events with 100% accuracy and with no other activity triggering a false negative. This work addresses the real need to help ensure the elderly can live independently, whilst ensuring timely responses to fall events. Future work will include further algorithm development to combine fall detection with other outputs such as heart rate and temperature to increase data collected to facilitate post-fall treatment. The next iteration will also implement a Smartphone to enable real-time alerts directly to the caregiver.

Publications

[1] P Catherwood, et al. ECG Motion Artefact Reduction Improvements of a Chest-based Wireless Patient Monitoring System. CinC2010, 26/9/10–29/9/10.

2] R. Harper, P.A. Catherwood, et al. Evaluation of a CE Approved Ambulatory Patient Monitoring Device in a General Medical Ward. Engineering in Medicine and Biology Conference, 31/8/10 – 4/9/10.