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Flexible Detection of Fall Events Using Bidirectional EMG Sensor

Hao Han[a], Xiaojun Ma[b], Keizo Oyama[c]

[a] *The University of Tokyo Hospital, Tokyo, Japan,*
[b] *The University of Tokyo, Tokyo, Japan,*
[c] *National Institute of Informatics, Tokyo, Japan*

Abstract

Falling is one of the most serious life-threatening events for the elders, and the growing population of elderly people motivates the development of ICT-based healthcare-oriented solutions for fall detection prevalently. In this poster, a bidirectional EMG (electromyographic) sensor network model is proposed for a more efficient and flexible detection of fall events based on simple communication between users and nursing care staff.

Keywords:
Fall Detection, Healthcare, Electromyographic Sensor

Introduction

As a nation running ahead of the curve in coping with the problems of an aging population, Japan has to face up the problem of a serious shortage of nursing care staffs in small and rural hospitals and healthcare facilities for the elderly. In this poster, we propose a wearable bidirectional EMG sensor network for flexible communication between users and nursing care staffs, and explain that this solution performs more realistically and rationally.

Wearable Bidirectional Sensor Network

For fall prediction, the analysis of health and medication data extracted from EHR (Electronic Health Record) is conducted [1]. However, it cannot realize a real-time prediction. Single-direction communication, such as surveillance camera and nurse call, is inefficient, and a simple "call/reply" interactivity is more effective in falls prevention [2] and could reduce workload of nursing staffs. We aim to detect falls with high positive predictive value and sensitivity, which means most real falls are correctly detected and less false falls are wrongly recognized. An interactive communication is provided between nursing care staffs, users, and the sensor network for releasing nursing workloads. When the fall prediction works, the users are soon warned, and when the fall detection fails, nursing staffs are called for helps through a light and easy-to-use interface.

An armband-type EMG sensor is imported to evaluate and record the electrical activity generated by skeletal muscles since arms give a sudden movement naturally and instinctively to stop falls. The sensor is also equipped with Wireless LAN, gravitational acceleration and gyroscope sensor. Through wearable sensor, the live logs are collected and stored in real-time. Live logs contain the continuous information of location (estimated by trilateration), status of movement and arm electromyogram data of users. The nursing staffs can learn the status of target users through the monitoring anytime. The collected live log is analyzed in real-time, and the fall alarm (location and user profile) is sent to nursing staffs if a fall event is detected (one of fall patterns is matched). Moreover, a vibration "call" (trigger built-in vibration motor) is remotely sent to the sensor as a confirmation for a possible "reply" from the detected target user. The nursing staffs run to the fall location to help fallen users, or stop the help if they receive a cancellation "reply" from the user. Here, by repeating a predefined special hand gesture (e.g., hold fist and rotate) which is seldom occurred in general life and easily learnt by the elderly, users can send a "call/reply" message to the system as a simple and quick communication between users and nursing staffs when a wrong or missed detection happens. Moreover, based on the analysis of personal activity patterns, fall history records, profile information and various statistics (e.g., dangerous areas like stairs), a user-oriented customizable prediction mechanism is constructed. If a possible coming fall is predicted, a notification "call" is sent to the sensor as a warning message.

Results

Thirteen (13) panel users assisted our experimental data collection by wearing the armband sensor on their right forearms in activities of walking/sitting/falling/leaning (arms against wall to stop a fall). Through the raw data, we can find that the acceleration and gyroscope sensor data are not adequate enough to clearly recognize the falling since there were many slow-falling instead of sudden and fast falling. Therefore, the analysis of EMG data would contribute to a more precise fall detection as an important detection factor since there were violent fluctuations in the signals of sensors at muscle near ulna and radius when the users fell or almost fell (leaning). Here, positive predictive value = 81.8% and sensitivity = 69.2%, which performs better than sensors without EMG data.

Conclusion

A model of bidirectional EMG sensor network is designed to detect/prevent elder-oriented fall events, and EMG data was proved to be contributing factors of a more precise detection and prediction result. As future research, we plan to explore further the problems of fall pattern learning and recognition based on gathering more real data.

References

[1] S. Yokota and K. Ohe, "Construction and evaluation of FiND, a fall risk prediction model of inpatients from nurs- ing data", Japan Journal of Nursing Science, 2016.

[2] R. A. Kenny, C. N. Scanaill, and M. McGrath, "Falls Pre- vention in the Home: Challenges for New Technologies", J. Soar, R. Swindell, and P. Tsang, Eds. Information Sci- ence Publishing, 2011.

Address for correspondence

Hao Han can be contacted at: han@hcc.h.u-tokyo.ac.jp