Using fractal dimension derived from trajectory measured by motion sensing carpet to assess wandering behaviors of dementia patients

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1. Background and purpose of the research

Wandering is a prevalent behavior in dementia patients. Warren (1999) compared the frequency of wandering. Of the 638 community-residing dementia patients examined, wandering behavior occurred in 17.4% of participants. It was significantly more prevalent in patients with Alzheimer dementia than those with vascular dementia or other dementia. Martino-Saltzman et al. (1991), characterize ambulation in older people with dementia according to its geographical pattern as direct, lapping, pacing, or random. Travel efficiency (percentage of direct travel) was significantly related to cognitive status (r =0.56), with inefficient travel most prevalent in severely demented participants.

In recent years, a variety of assistive technologies based on “ambient-assisted living” (AAL) tools are developed to assess the wandering behavior. Kim et al. (2009) tried to distinguish wandering patterns from normal patterns in a nursing home by using triaxial accelerometer sensors. Campo et al. (2010) developed methods for determining normal trajectory classes and triggering alarms when the trajectories are unusual by using infrared sensors. Vuong et al. (2014) automatically classify wandering patterns of dementia patients with active RFID system based on the Martino–Saltzman typology into direct, random, pacing, and lapping patterns. Kearns (2010) used “fractal dimension” (Fractal D), a measure of movement path tortuosity (directed vs. irregular or apparently aimless locomotion) to access wandering behaviors of dementia patients. Ultra-wideband sensors were used to measure day time locomotion to an accuracy of 20 cm in 14 elderly residents in an assisted living facility. Fractal D was found to be significantly and negatively correlated with cognitive status as measured by the Mini Mental State Examination (MMSE) administered to each participant at the study’s end. The purpose of the research is to use fractal dimension derived from trajectory measured by motion sensing carpet to assess wandering behaviors of dementia patients. In the initial study, this system has been implemented in the rooms of 4 demented older adults to collect data.

2. Methods

*Whiz*Carpet is composed of 50cm×50cm “puzzle floor mat” modular motion sensing units, which can be assembled freely into any size and shape according to the setup of the home environment (Chang et. al, 2014). *Whiz*Carpet system was implemented in the rooms of 4 demented older adults in a nursing home in Tainan (Figure 1, left). Four residents (A, B, C, D) are 82, 66, 85, 85 years old, respectively. All four participants are diagnosed with dementia. Two of them are wanderers (A, B), and the other two are non-wanderers (C, D). The locomotion data was collected by a microprocessor and transmitted to the cloud server, and can be display on an App graphically in real time (Figure 1, right).

Figure 1. *Whiz*Carpet implemented in the nursing home

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Wandering events were identified and stored in the cloud server. Fractal D was calculated for each event. Figure 2 shows the duration, travel rate and fractal D of four typical wandering events: direct (Figure 2(a)), pacing/lapping (Figure 2(b)), random (Figure 2(c)).

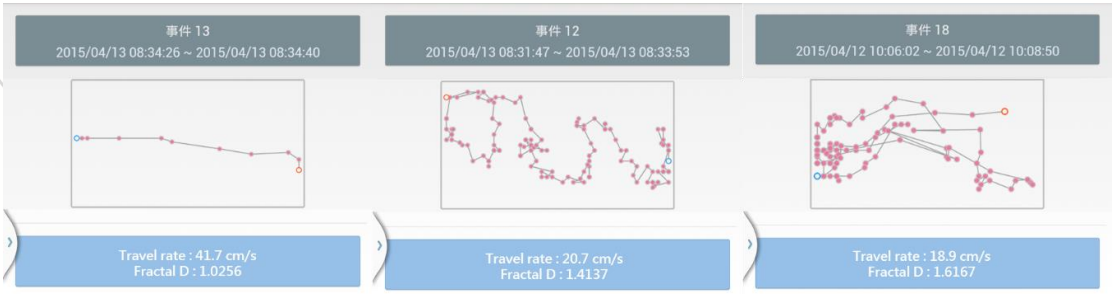

Figure 2. The duration, travel rate and fractal D of four typical wandering events

3. Results and future work

Figure 3 compares the wandering events collected on a day between participant A (wanderer) and C (non-wanderer). The mean of Fractal Ds of the 27 wandering events of participant A is 1.298 (SD=0.25); while the mean of Fractal Ds of the 43 wandering events of participant C is 1.149 (SD=0.17). With the promising initial results, we are tuning the algorithm and collecting long-term data of the 4 residents.

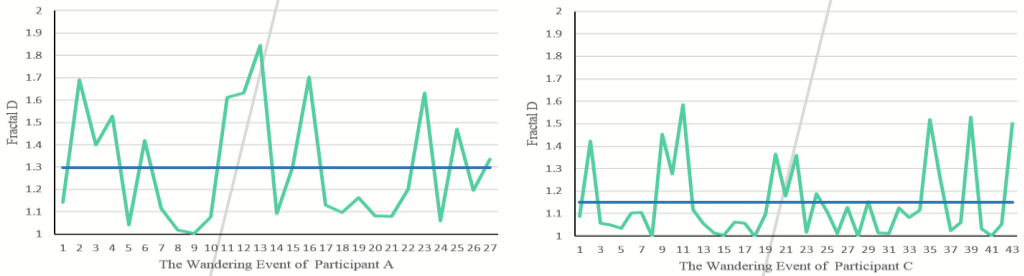

Figure3. Wandering events collected on a day of participant A (wanderer) and C (non-wanderer)

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