Multi-depth cameras system for bed exit and fall prevention of hospitalized elderly patients

T. K. Shea, Y. C. Tam, P. H. So, T. C. Chan, H. Y. Mak, K. H. Lai, M. W. Wong, Y. P. Zheng, C. W. Cheung

Purpose Wandering behaviors of the elderly are linked to high morbidity and mortality rates ascribed to falls, fatigue, psychological distress, and accidental exposures (Silverstein et al., 2018). To prevent wandering behavior, dangerous craning over the fence, and fall in hospitalized elderly patients, physical or virtual restraints are often used to restrain patient on the bed or alarm when bed exit is detected. These methods however have ethical concerns or have high false alarm rates. The proposed elderly wandering monitoring system was previously developed and implemented in nursing homes and residential care homes and showed promising results (Cheung et al.,2021, Cheung et al.,2022). However, the existing system with ceiling mount design from a single side view showed a limitation of blockage by subject activities, equipment, and furniture. Multiple cameras mounting from different angles could overcome the issue, particularly in wards in hospitals, where activities blocking the field of view of a single camera could be carried out multiple times daily. Hence, a new installation strategy with a new algorithm approach was implemented and tested. To test and evaluate the revised system, specific activities were performed by subjects and caregivers to mimic daily life and service activities. **Method** The system consisted of three infra-red 3D time-of-flight (ToF) sensors (Realsense Depth Camera, Intel, USA, with its Red Green Blue (RGB) camera disabled and concealed) each attached to a Raspberry Pi 4 (Raspberry Pi single-board computer, Raspberry Pi Foundation, UK) networked computer unit as main hardware with supporting software and algorithm. Three sets of sensors were mounted on the ceiling above the center, headboard, and the foot of the bed, respectively. A decision tree algorithm was used to determine the best-unblocked depth camera. Virtual boundaries were set in the depth image, including the bed zone, and the leave zone (Figure 1). The head of the patient was tracked using a correlation filter method to determine if the patient was in the bed zone or leave zone (Figure 2). Professional nurses working in the Queen Elizabeth Hospital were invited to be the participants in this experiment. 24 participants were divided into 8 groups, in turn, 1 was a patient and 2 were nurses to mimic daily activities in the hospital. 20 scenarios were designed and discussed with 10 professional nurses in the hospital and were performed by the participants, with 10 scenarios that have no fall hazard and 10 scenarios that were either bed exiting or had fall hazards. The head positions of the patients were assessed in the 20 scenarios to study the differences between hazardous and non-hazardous scenarios. **Results and Discussion** The multi-depth cameras system allowed the tracking of patients to be less affected by a physical blockage than from a single view angle. Tracking the patient's head using the correlation filter method helps to identify a high fall risk posture of the patient or when a patient is exiting the bed.

References

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Address: Department of Biomedical Engineering, The Hong Kong Polytechnic University, Hong Kong, China
Email: queenietk.shea@polyu.edu.hk

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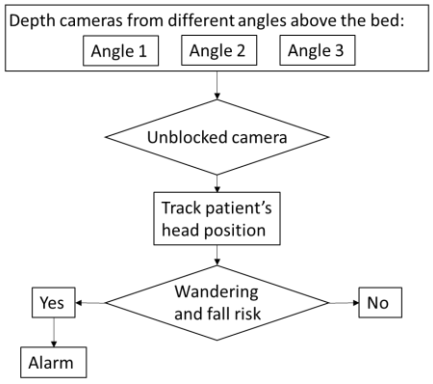

Figure 1. System designed for fall risk alarm

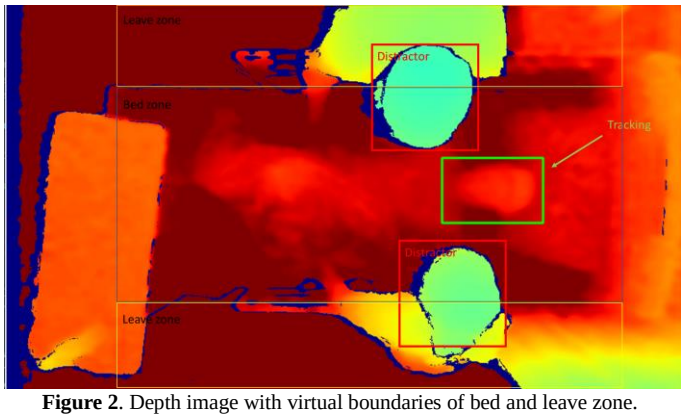

Figure 2. Depth image with virtual boundaries of bed and leave zone. The Head of the patient and distractor (nurse) were identified