Using machine learning for in-bed posture classification, sleep and daily pattern recognition on a motion-sensing mattress

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Purpose A motion-sensing mattress is developed to collect the real-time in-bed motion data from the 6×5 pressure sensing areas. Falls are a common occurrence among hospital inpa-tients, causing major injuries (Lee et al., 2014). Most devices providing leave-bed alert send the alert after the patient leaves the bed, which is often too late. In this study, machine learning is used to identify the in-bed postures. The purpose is to capture the intention of the patient and send out early alerts to the nursing station. Ma-chine learning is also used to score sleep/wake using bed actigraphy data obtained from the motion-sensing mattress in comparison with scoring from polysomnography (PSG). Finally, the daily living pattern of individual users can be established from the long term data collected by the motion-sensing mattress. M**ethod** Thirty-one participants in 5 different weight groups were recruited for posture identifica-tion. Each participant was requested to repeat the three in-bed postures (lying on the bed, sitting on the bed, sitting on the edge of the bed) several times, for a total of 30 exam-ples collected from each participant. In addition to the 930 examples collected from the participants, we created 80 examples to simulate "empty bed," with pillows, blankets put randomly on the bed. Twenty participants were recruited for sleep/wake using bed actig-raphy data obtained from the motion-sensing mattress in a sleep-lab setting. Each partic-ipant sleep on the motion-sensing mattress for two hours. 30-second episodes of data from the motion-sensing mattress and the PSG were collected. **Results and Discussion** Tensor Flow was used to create the machine learning model for posture identification. Multilayer perceptron was used in machine learning. The accuracy is 97.38%, ROC area is 99.7%. The machine learning model was then coded in the microcontroller of the motion-sensing mattress. Twelve participants were recruited to test by actually lying on the mat-tress in different postures. In a total of 360 test examples, the accuracy was 93.12%. Tensor Flow was also used to create the machine learning model for sleep/wake scoring using bed actigraphy. Compared with the scoring from PSG, the accuracy is 88.96%. In particular, the sensitivity of awareness is 69.2%. This machine learning model was then employed in the cloud. Ten motion-sensing mattresses were installed in a nursing home for long-term data collection for three months. Figure 1 shows an example of a long-term in-bed pattern of an older adult. The daily living pattern of the older adult can be estab-lished using 70% as the threshold. Typically, the older adult (1) Gets up no earlier than 05:50; (2) Gets up no later than 07:30; (3) Not in bed during the day; (4) Goes to bed no earlier than 19:00; (5) Goes to be no later than 20:40; (6) average in-bed time 45.88%. A alert message can be issued if the living pattern is different from routine on a given day.

References

Lee, D. C. A., Pritchard, E., McDermott, F., & Haines, T. P. (2014). Falls prevention education for older adults during and after hospitalization: a systematic review and meta-analysis. Health education journal, 73(5), 530-544.

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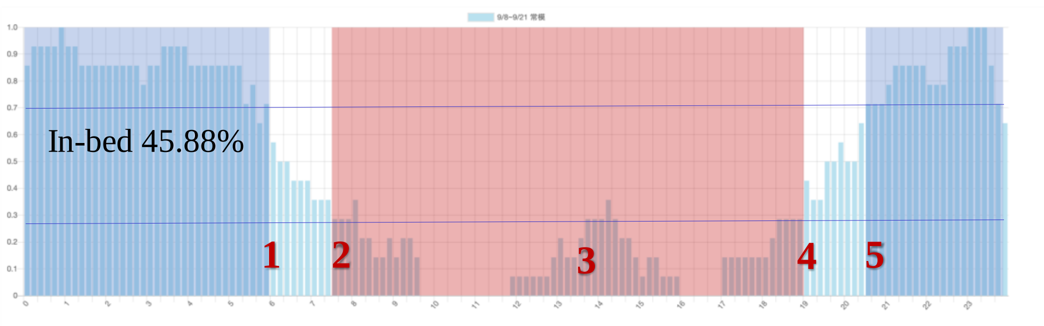

Figure 1. An example of a long-term in-bed pattern of an older adult. The horizontal axis is the time of the day; the vertical axis is the long-term in-bed percentage.