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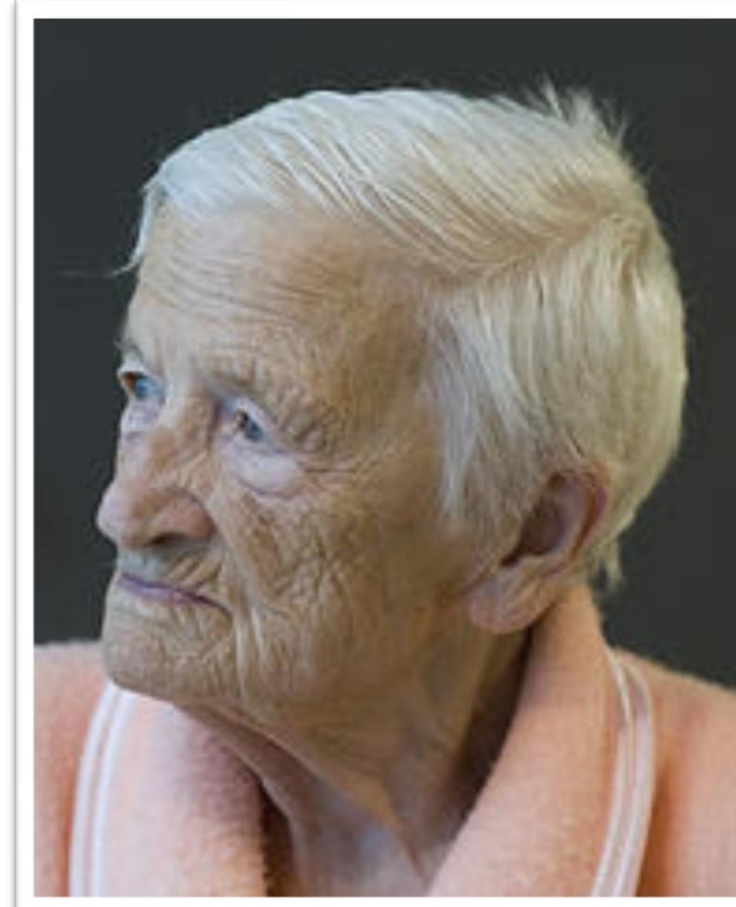
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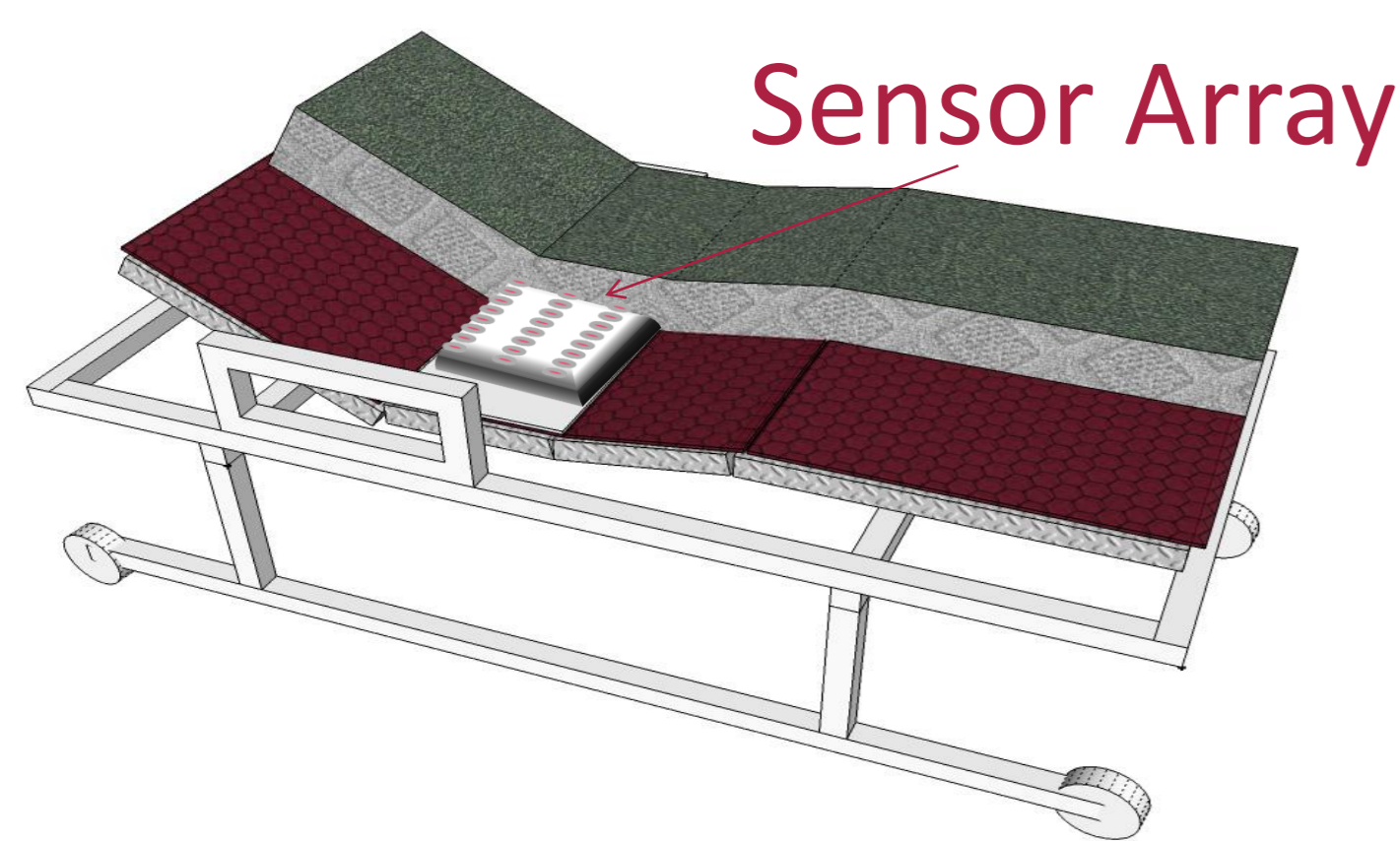
Introduction

Palliative care needs are rising in Canada. Home-based palliative care services could alleviate some of the strain on the health system, while simultaneously fulfilling palliating patients' desires to be cared for at home.

Currently, palliative care patients are monitored intermittently, usually through questionnaires. Methods of monitoring these patients continuously and unobtrusively, without detracting from their quality of life, could improve symptom control and comfort in end-stage pulmonary, cardiac and neurological diseases.



Sensor Processing

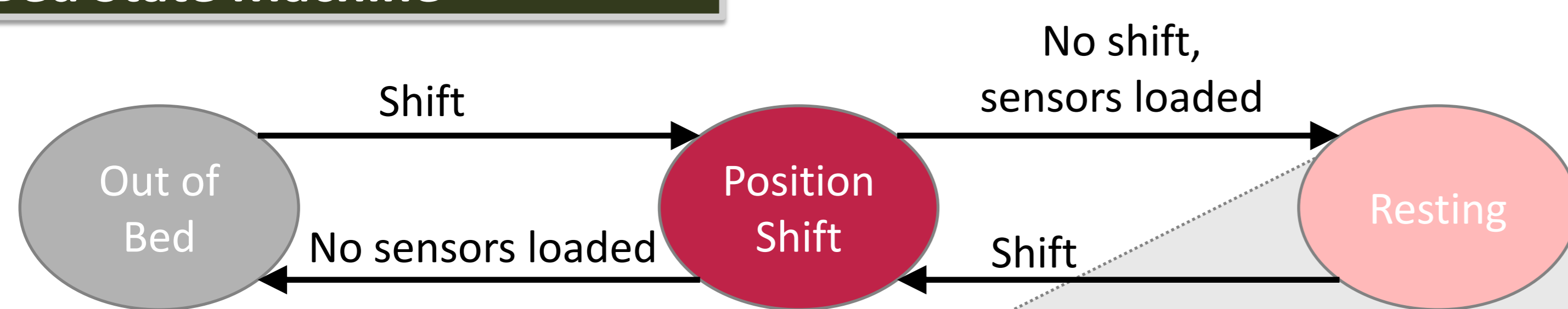


Sensor Array

A grid of pressure sensors is placed below a mattress to record pressure changes in the bed.

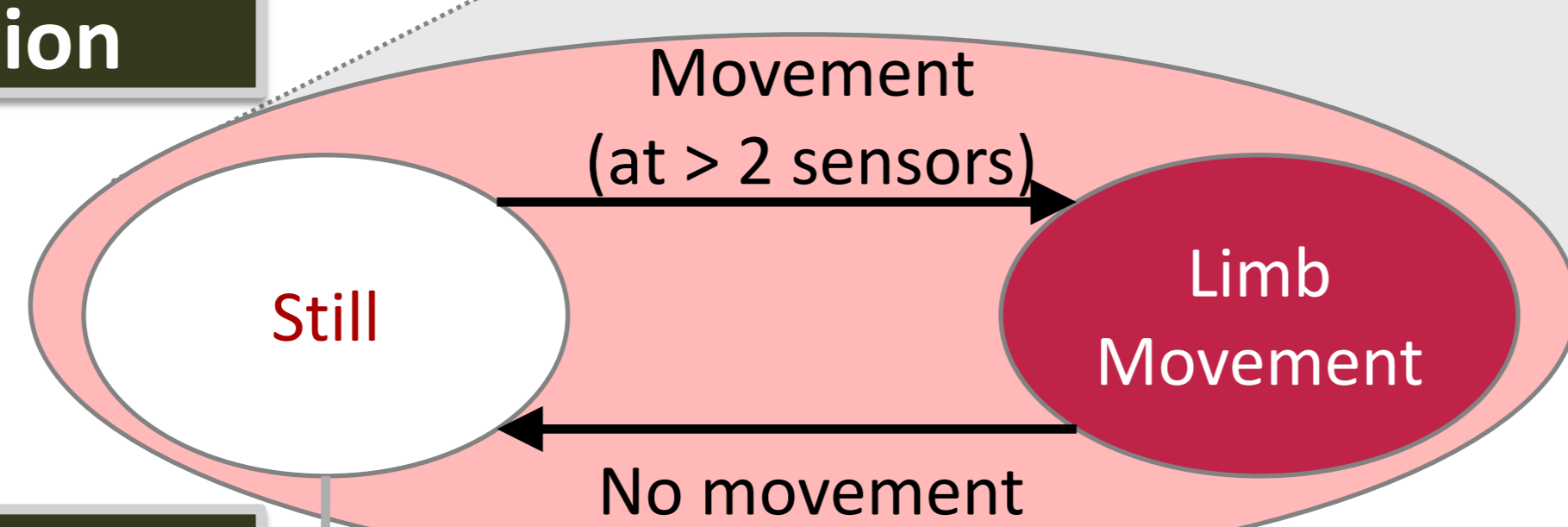
A state machine segments the data into periods of rest, out-of-bed, and position shifts. The resting data is then used to further classify limb movements and periods of stillness for breathing analysis.

Bed State Machine



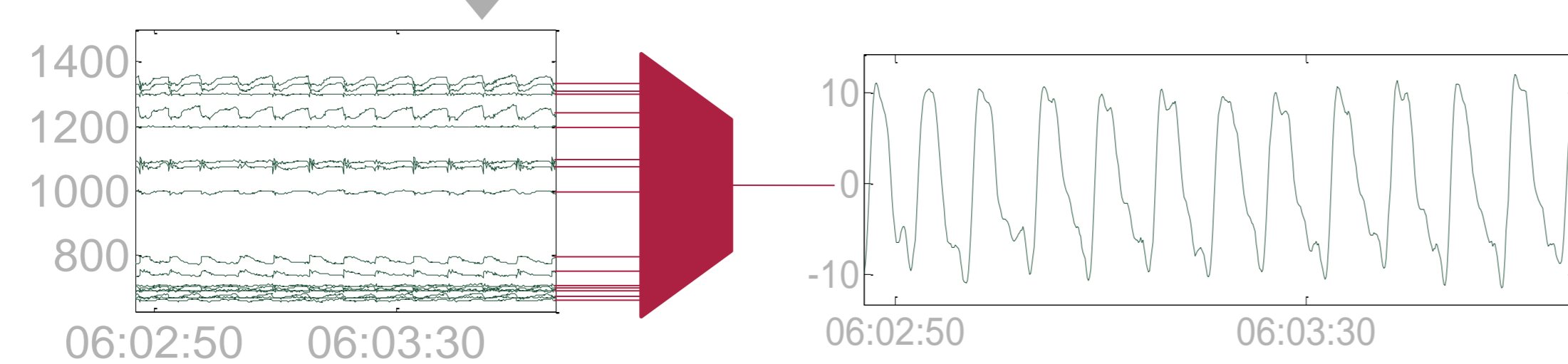
Limb Movement Detection

Change detection via Shewhart Control Limits is used to detect limb movements.



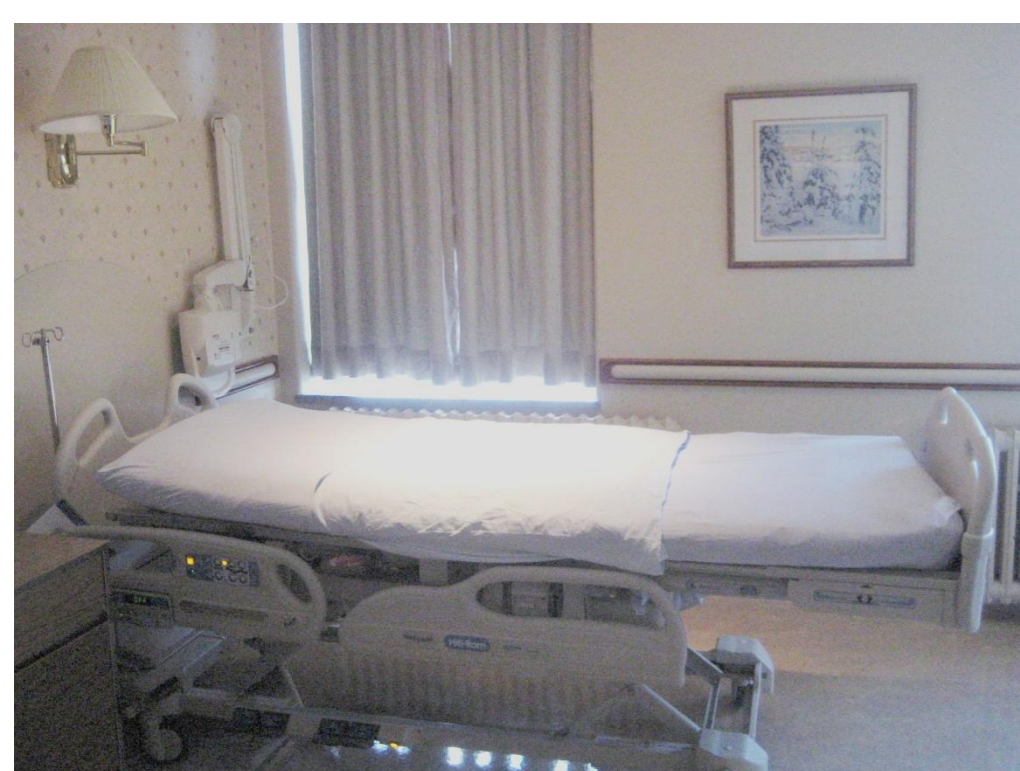
Breathing Fusion

Breathing is fused from sensors using maximal ratio combining, after first detecting signal polarity reversals.



Experiment

Two patients with lung cancer in the Palliative Care Ward at Elisabeth Bruyere Hospital consented to be monitored using such an array while an observer sat in the room and manually logged their movements. Delirium questionnaire scores, or NuDesc scores, were also recorded.



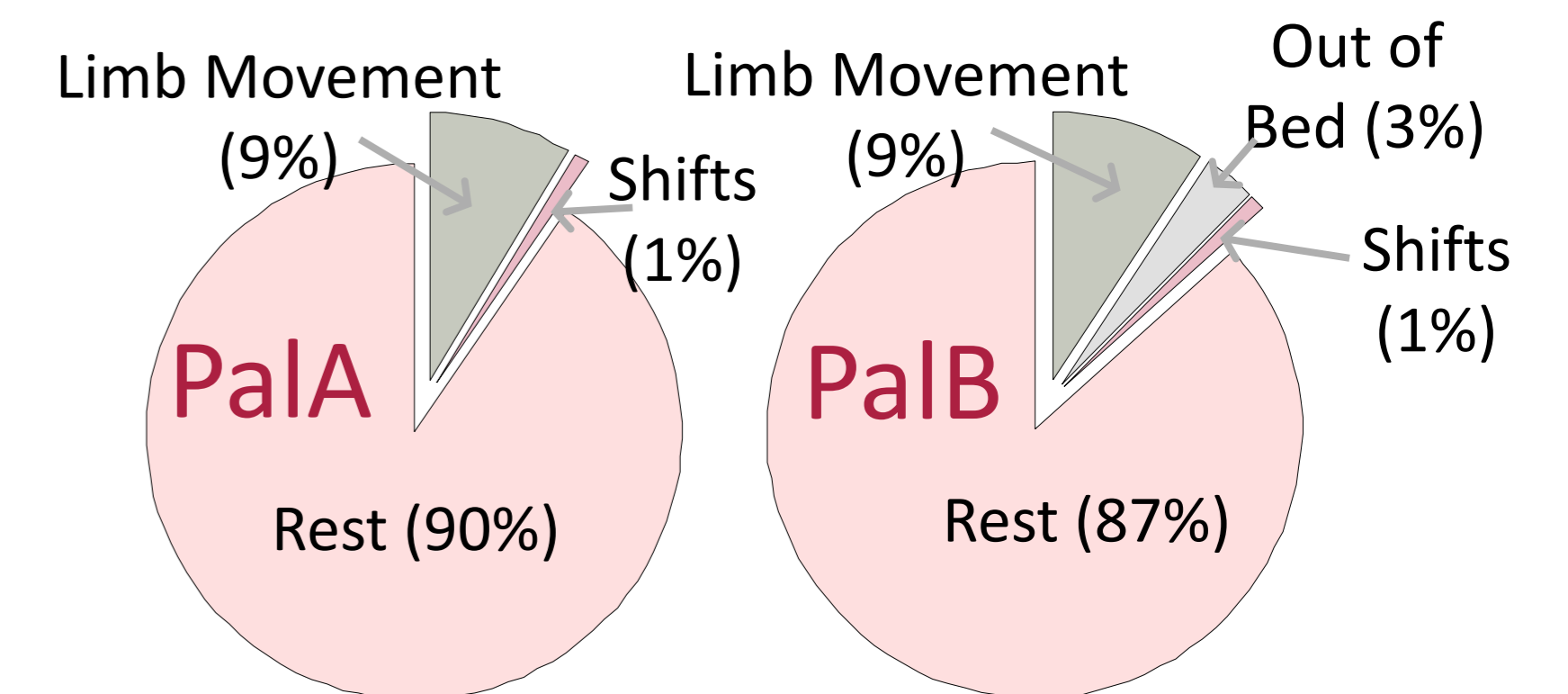
Participants	Time Span	Recorded Time	Age	Sex
PaLA	20 hrs	14 hrs	81	F
PaLB	55 hrs	14 hrs	55	M

Collected data were then processed as detailed above and compared to observer annotations.

Results

How Did They Spend Their Time?

Both PaLA and PaLB spent most of their time resting. Limb movements accounted for almost 10% of their time in bed, but shifts in position were only 1%.



Both had very similar profiles of time spent, but PaLB spent time out of bed.

Event Detection Accuracy

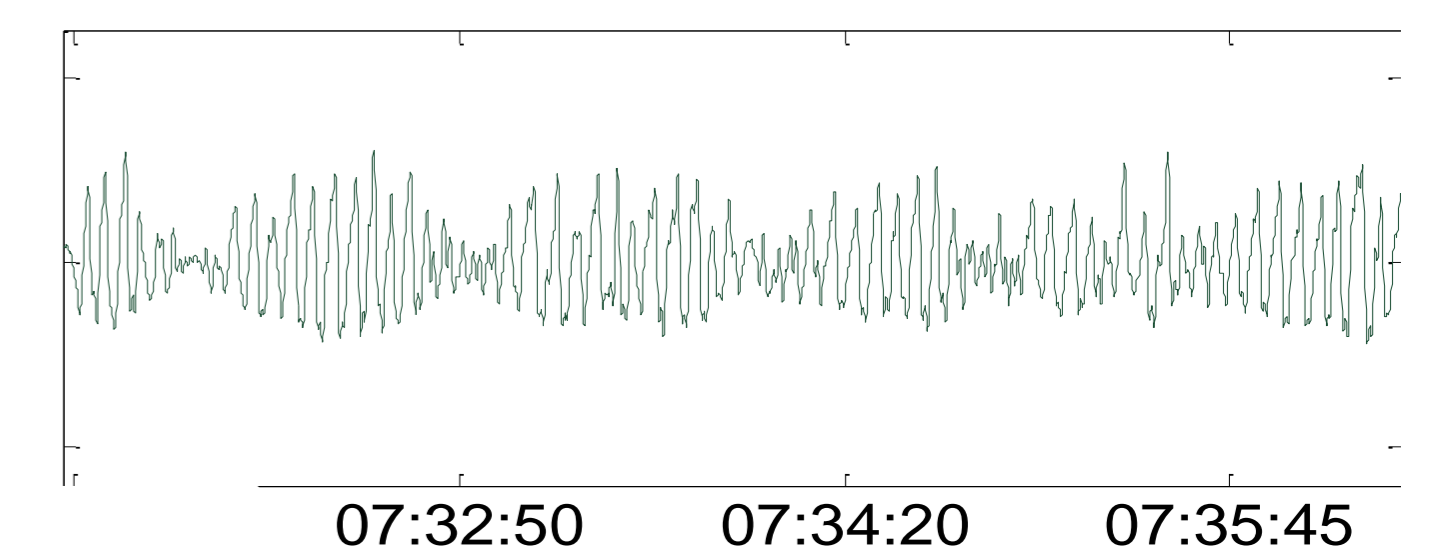
	Sensitivity	Specificity
Out-of-Bed Detection	100%	100%
Position Shift Detection	80%	96%
Movement Detection	100%	80%

The system detected three times as many movements as the observer did, particularly during sleep. These may not be false alarms, but simply a greater sensitivity to actual movement when lighting levels were low and movement was more difficult to see.

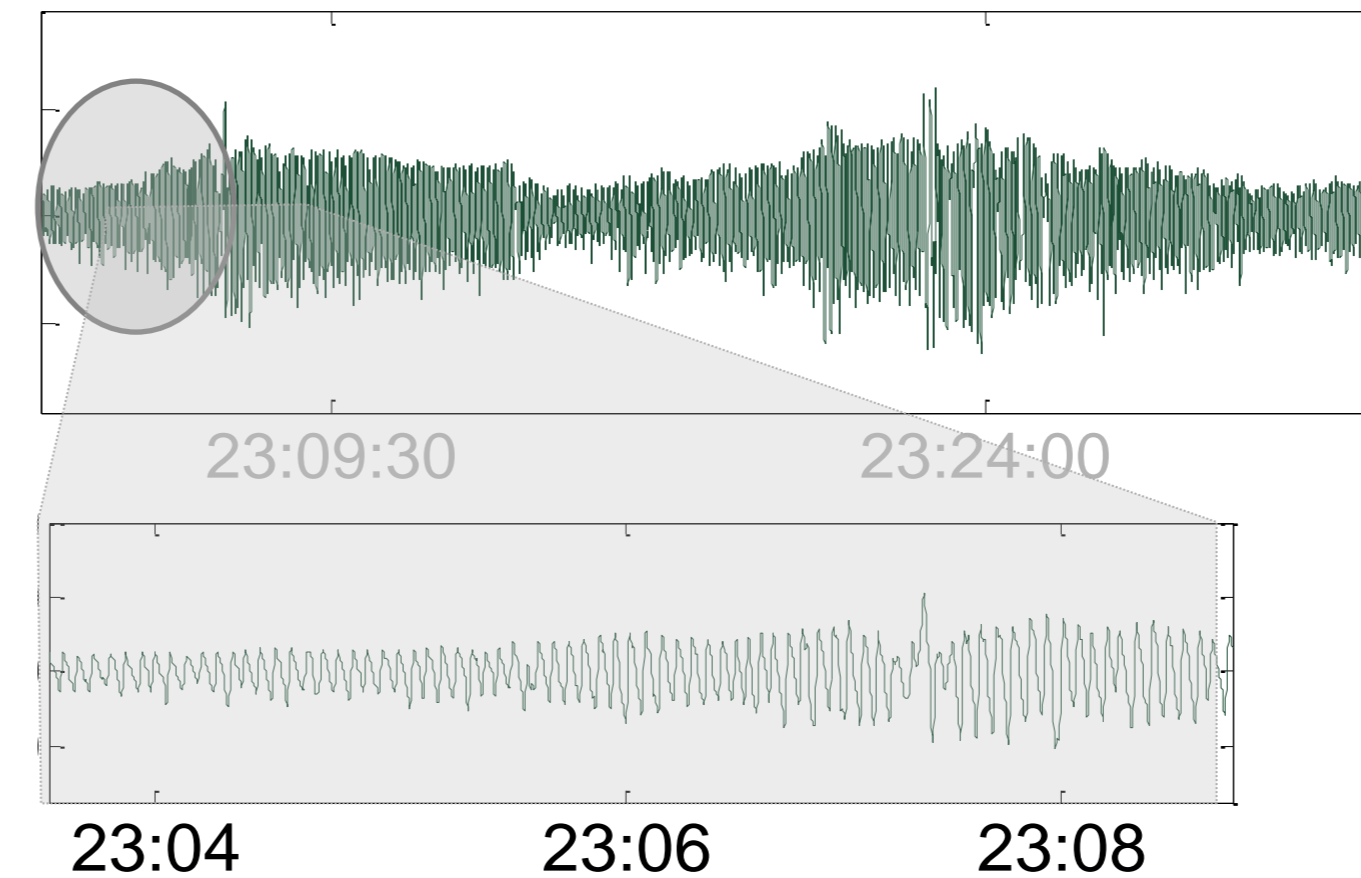
Observed Breathing Patterns

A number of interesting respiratory patterns were observed. PaLA had a half hour crescendo-decrescendo pattern and some periodic breathing segments. PaLB had many sections of generally disordered breathing.

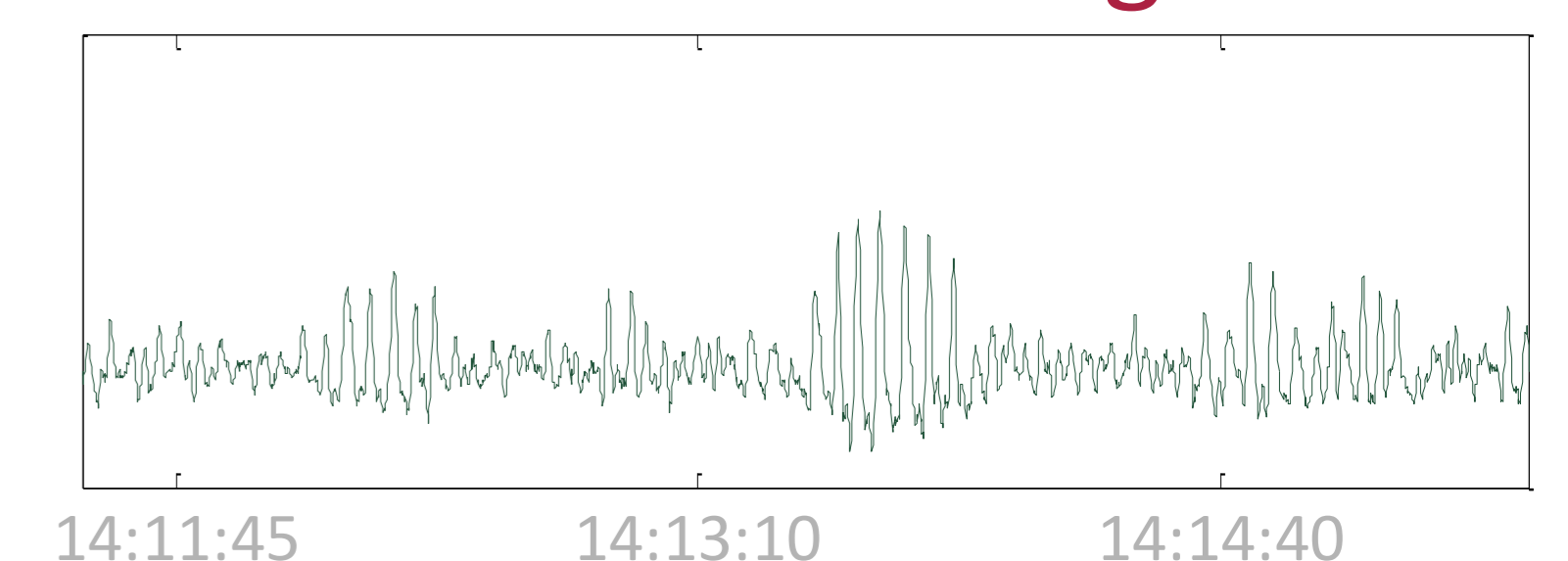
Periodic Breathing



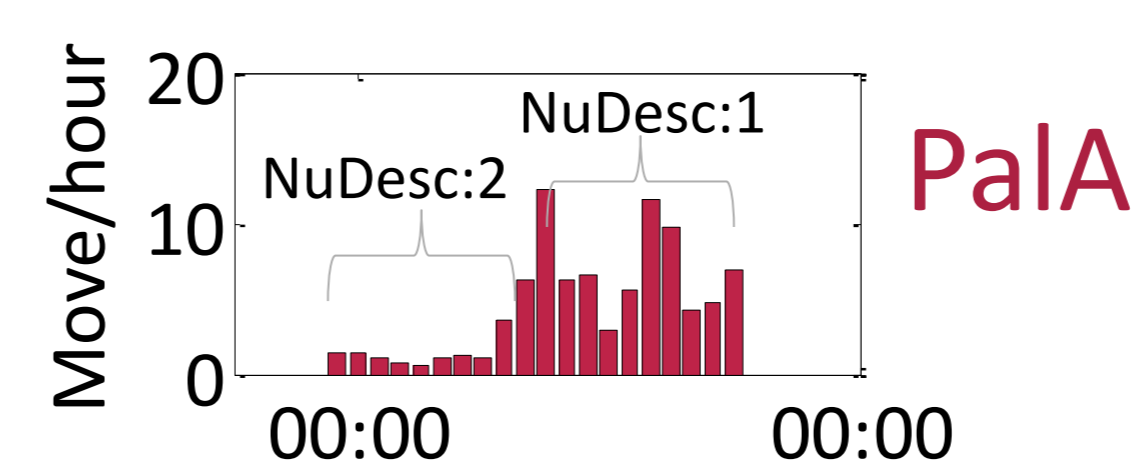
Crescendo-Decrescendo



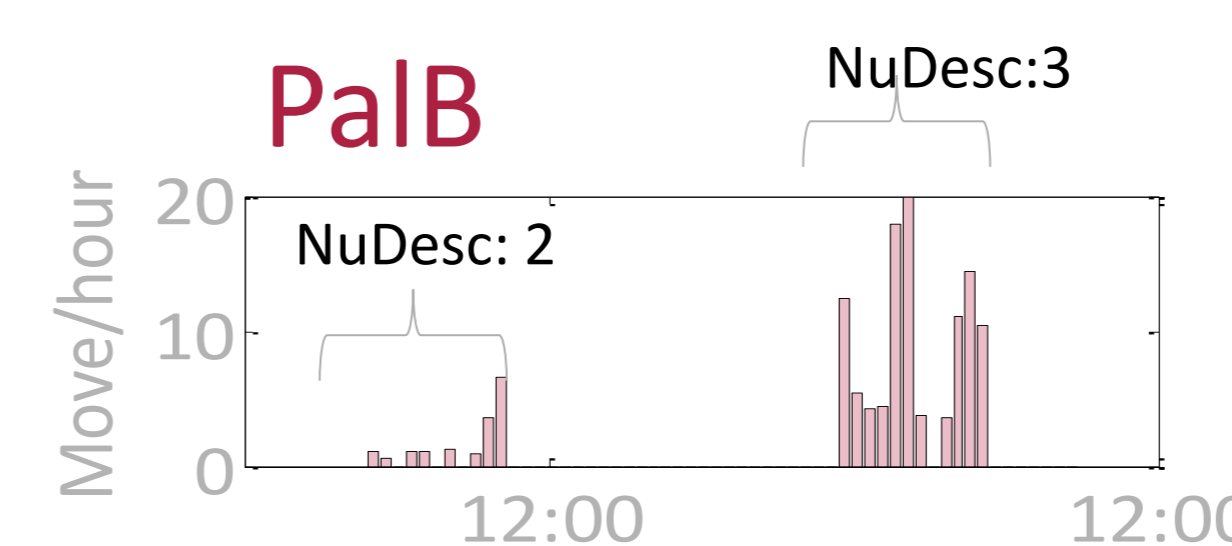
Disordered Breathing



Delirium Assessment



Agitation and movements are symptoms of delirium. NuDesc scores are labeled here, along with movements per hour. Although the data is too short for thorough analysis, it does yield some clues.



Overnight movement counts may be more valid than daytime counts, when activities of daily life occur. PaLA shows an increase in movements per hour during the day, but a decreased NuDesc. PaLB shows an increased number of movements per hour on the second night compared to the first, as well as a higher NuDesc.

Conclusions

Motion analysis from under-mattress pressure sensors yields useful clinical parameters. With continuous information from the unobtrusive system, indications of mortality, delirium, and respiratory distress could be explored. Research is also required to investigate methods to separate movements initiated by caregivers and loved ones from movements made by the patient independently.

This ambient system is appropriate for both the institutional and home environments and could provide never-before-seen information about disease progression and the end of life.

Contact Us

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More information

More information on this and other related projects can be found at
<http://www.tafeta.ca>