AUTOMATED ASSESSMENT OF MOBILITY IN BEDRIDDEN PATIENTS

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1. INTRODUCTION

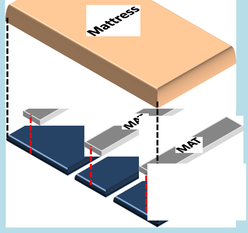
	Recorder's Initials	BL	Example 1 Days 01-03			Example 2 Days 03-06		
	Date Assessed (DD)	01	13	16	17	18	19	20
	(MM)	01	01	01	01	01	01	01
Score	Day	00	01	02	03	04	05	06
	BALANCE							
21	Stable ambulation	21						21
14	Stable dynamic standing		14				14	
10	Stable static standing			10		10		
7	Stable dynamic sitting				7			
5	Stable static sitting							
0	Impaired static sitting							
	TRANSFERS							
18	Independent and Vigorous	18						
16	Independent							16
14	Independent but slow		14				14	
12	1 person standby			12		12		
11	1 person minimal assistance				11			
7	1 person assist							
3	2 person assist							
0	Total lift							
	MOBILITY							
28	Unlimited, vigorous	28						
26	Unlimited							26
25	Limited >50m, no aid							
21	Unlimited, with aid		21				21	
19	Unlimited with aid, slow							
18	With aid >50m			18		18		
16	No aid, limited 8-50m				16			
15	With aid 8-50m							
14	With aid <8m+							
12	1 person standby/+/- aid							
9	1 person hands-on/+/-aid							
7	Lying-sitting independently							
4	Positions self in bed							
0	Needs positioning in bed							

Example HABAM Assessment Form

- In older patients, impaired mobility is a complex phenomenon and can often be a sign of underlying disease [1].
- The Hierarchical Assessment of Balance and Mobility (HABAM) is a clinical tool that monitors elderly patient health by assessing the ability to move, and has been shown to predict morbidity [2].
- The addition of any clinical tool that takes nurses away from patient care is not currently a popular idea, and so the automation of HABAM may be an important informative addition to many hospitals.
- This paper explores a volunteer-based, partial automation of the HABAM tool, focusing on the assessment of in-bed HABAM scores as a precursor to studies in bedridden patients.

2. METHODS

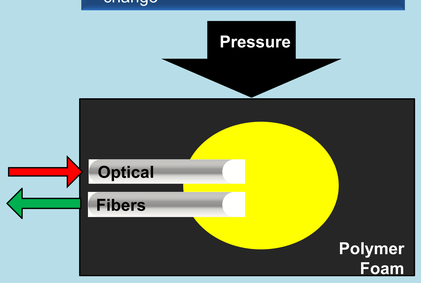
Equipment Set-Up



- One hospital bed was equipped with three pressure mats.
- Each mat contains polymer foam, embedded with a 3x8 fiber optic pressure sensor array.

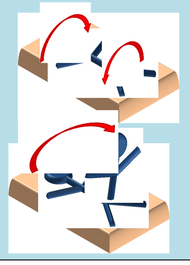
Pressure Sensors

Pressure Sensors
- Light from an LED is sent to an integrating cavity, by one optical fiber (red) and is received by the other (green).
- When pressure is applied, the light is scattered and the signal reflects this change



Experimental Methods

Data was collected while 5 volunteers performed 3 entirely in-bed enactments of HABAM scores. These scores were: a score of 0 for 'Needs positioning in bed', a score of 4 for 'Positions self in bed', and a score of 7 for 'Lying-sitting independently'.

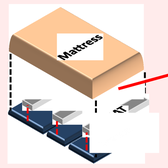


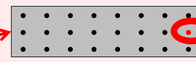
Score 0 (attempted roll) and 4 (full roll)

Scenario 3 (sit up from lying)

3. ANALYSIS

About 3 seconds of data was collected of the hospital mattress alone, and averaged for each sensor to eliminate the mattress weight.



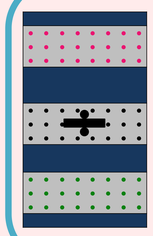


Red sensor
Time(s): 1 2 3
Scores: 200 201 198

$mav_{redsen} = (200+201+198)/3sec$

All subsequent movement data was then zeroed

$zeroed_{sensor}(t) = rawdatasensor(t) - mav_{sensor}$



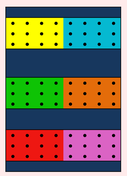
$sum_{head}(t) = \sum head(i,j)(t)$

$sum_{foot}(t) = \sum foot(i,j)(t)$

$ratio_{hf}(t) = sum_{head}/sum_{foot}$

If $ratio_{TB}$ started above 1 (Bottom mat experienced 100% more pressure than the top mat) and dropped below 1, the data was considered to represent:

Score 7: lying-sitting



The sensors were considered as part of a group representing a respective mat area. $base_{sensor}(t)$ is each sensor's average score of the first 4sec (subject's initial position)

% ↑ $pinc_{sensor}(t) = \frac{\|zeroed_{sensor}(t) - base_{sensor}(t)\|}{base_{sensor}(t)}$

% ↓ $pdec_{sensor}(t) = \frac{-\|zeroed_{sensor}(t) - base_{sensor}(t)\|}{base_{sensor}(t)}$

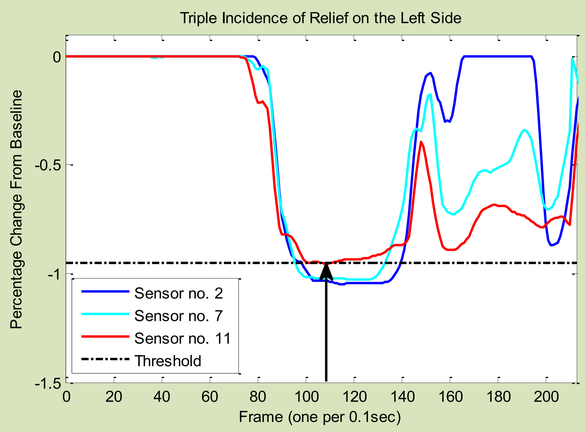
Then a moving average filter (W=5) was then applied

A TOTAL RELIEF OF PRESSURE MEANS % ↓ = 1.0

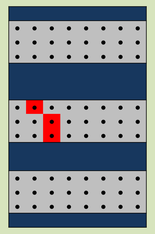
IF 2+ SENSORS IN THE SAME AREA HAD % ↓ <0.95

Score 4: Positions self in bed
OTHERWISE
Score 0: Needs positioning in bed

4. RESULTS



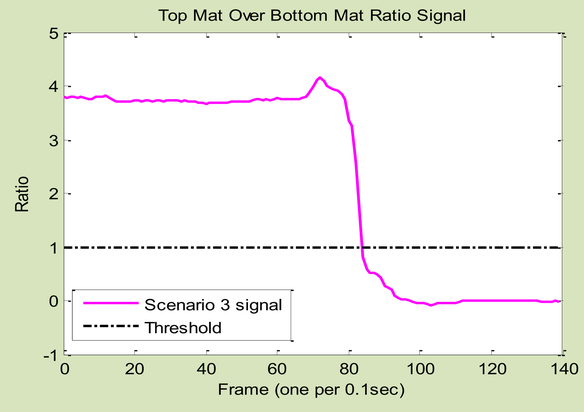
An example of a successful lying to sitting transfer



An example of a successful left hip lift, and the sensors involved.

Enactments of scores and resulting system assessment

Participant	HABAM Score Enactment		
	Score 0	Score 4	Score 7
1	4	4	7
2	0	4	7
3	0	4	7
4	0	4	7
5	4	4	7



The overall results. The results highlighted in yellow were unexpected, but upon review, correct.

5. CONCLUSION

- Examination of the results indicated that this system is capable of determining between the three HABAM score enactments examined in this paper.
- Examination of data revealed that the system had not assessed incorrectly, but had captured an instance of pressure relief that went unnoticed. This result emphasizes the significance of ubiquitous computing in applications such as the HABAM, as data immeasurable to the eye is captured and recorded.
- The automation of HABAM could not only ensure consistent, reliable assessments and expand upon our knowledge of movement in the immobile, but could also emphasize the importance of pervasive computing in the assessment and tracking of immobility.

6. REFERENCES

1. R. Hubbard, and K. Rockwood, "Mobility and balance in older people," Can. J. Gen. Intern. Med., vol. 5, no. 1 pp. 13-15, April 2010.
2. D. Davis, M. Rockwood, A. Mitnitski, K. Rockwood, "Impairments in mobility and balance in relation to frailty," Arch. Geront. Geriatr., vol.53, no.1, pp.79-83.

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