

#D17



EYE-CU: SLEEP POSE RECOGNITION USING MULTIMODAL MULTIVIEW DATA

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Healthcare Problem

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Intensive Care Unit (ICU) Statistics

- 5 million** people per year are admitted to the ICU.
- 46%** are over the age of 65.
- Annual national ICU cost is **\$130 billion** and rising \$5 billion per year.
- Average duration of stay in the ICU is **9.3 days**.
- Mortality rate is **10-30%** and increases by **7%** per day.
- Year 2020 estimates:
 - ICU elderly population will **increase to 69%**.
 - Caregiver workforce will **shrink by 35%**.

Questions:

1. Why the ICU?
2. What are the problems?
3. How to help?

Effects of Poses on Patient Health

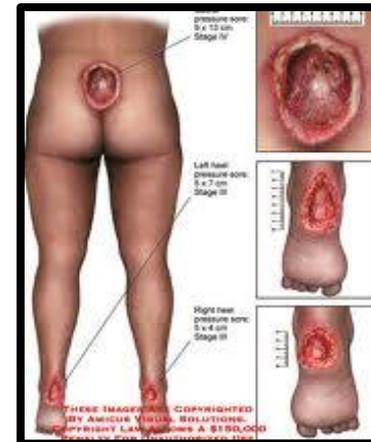
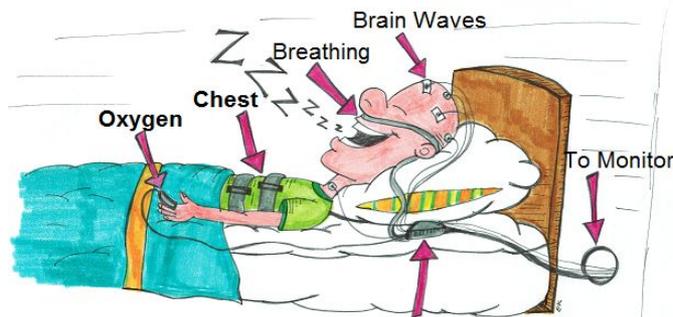
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Sleep Deprivation* - Sleep Hygiene

- ❑ “Bad night” → ICU stay + 10%
- ❑ Sleep poses → Quality of Sleep
- ❑ Obtrusive measurements + Surveys
- ❑ No prevention

Decubitus Ulcerations** - Bed Sores

- ❑ 2.5M (80% occur in ICU)
- ❑ Pose (Bony areas)
- ❑ Braden scale (subjective & observational)
- ❑ Rounds & Patient Rotation (2hr, <20%)



*Sleep in the Critically Ill Patient, Weinhouse and Schwab. Sleep 2006
Factors affecting sleep in the ICU. Bihari et al. JCSM 2012

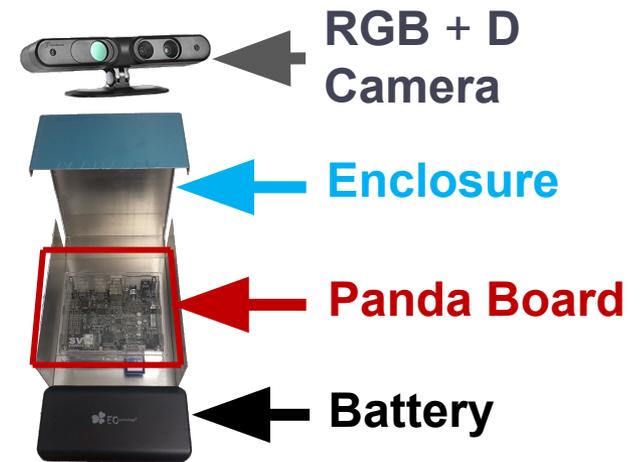
**Preventing Pressure Ulcers in Hospitals. Soban et al. Jnl on Quality & Patient Safety 2011
Online Medical-Dictionary: pressure ulcer, retrieved Feb 2016

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Data Collection



Dry Lab: Mock-Up ICU



Popular Techniques

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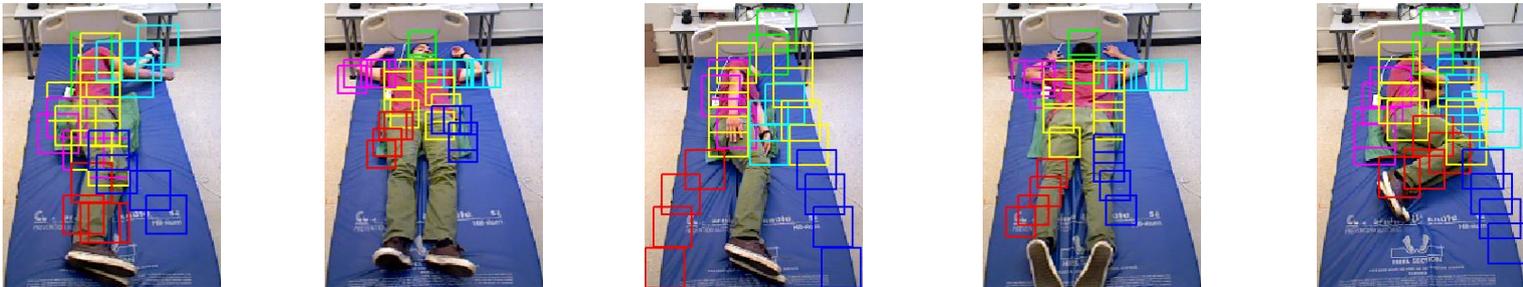
ASSUMPTIONS

- View Point and Depth Contrast
- "Good" Illumination
- No Occlusions

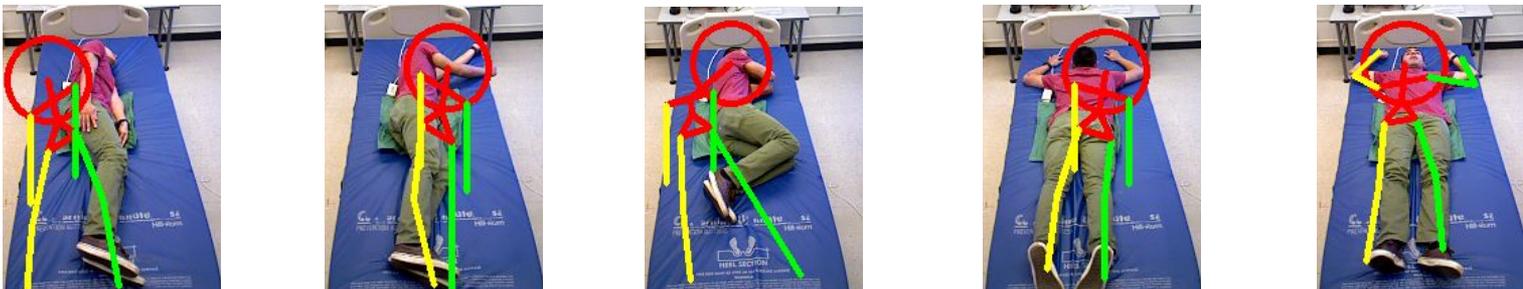
FAILURE CAUSES

- Clutter
- Minor self-occlusions
- Depth Contrast

1. Deformable Part Models



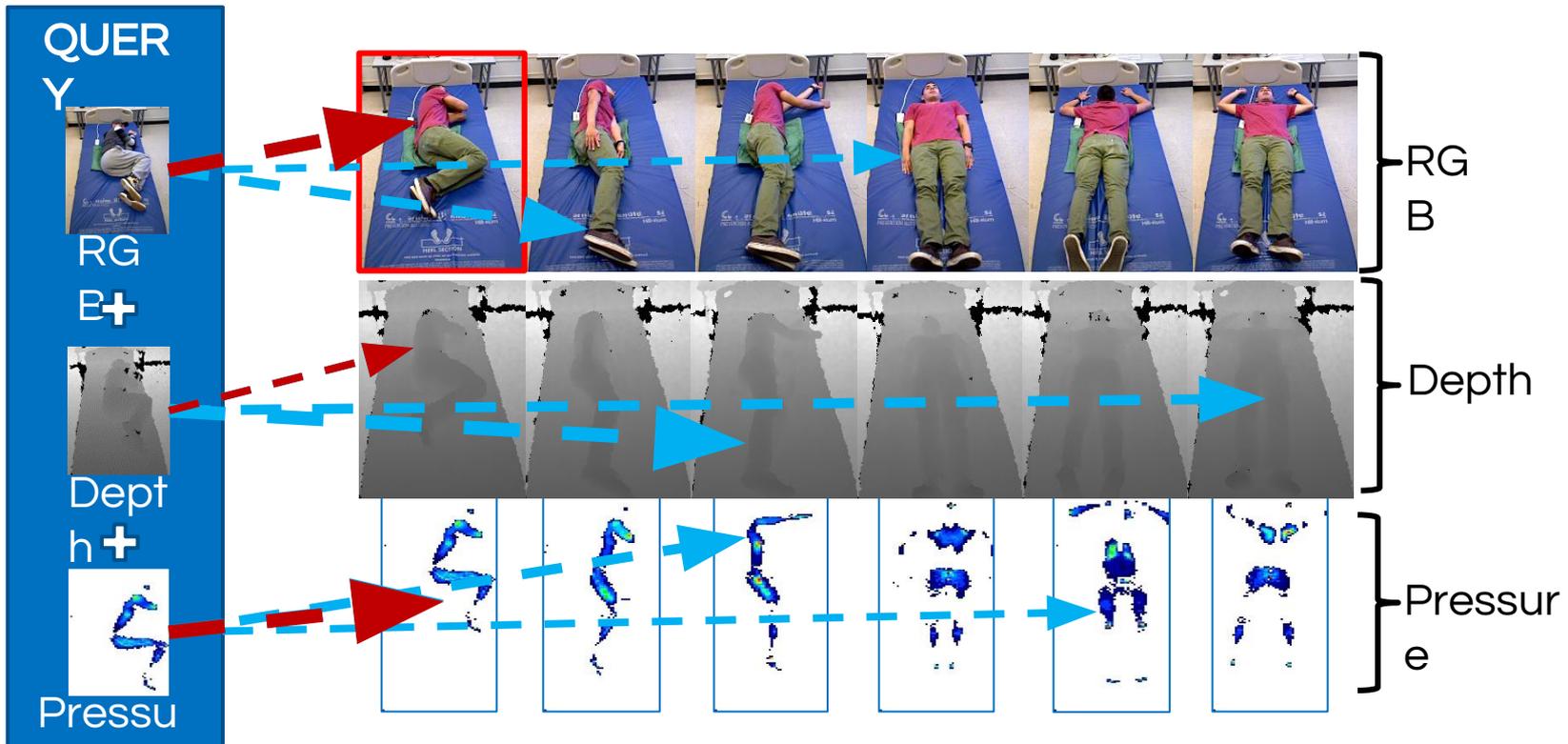
2. Kinect API



Can Multimodal Data Improve Performance?

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DICTIONARY OF POSES

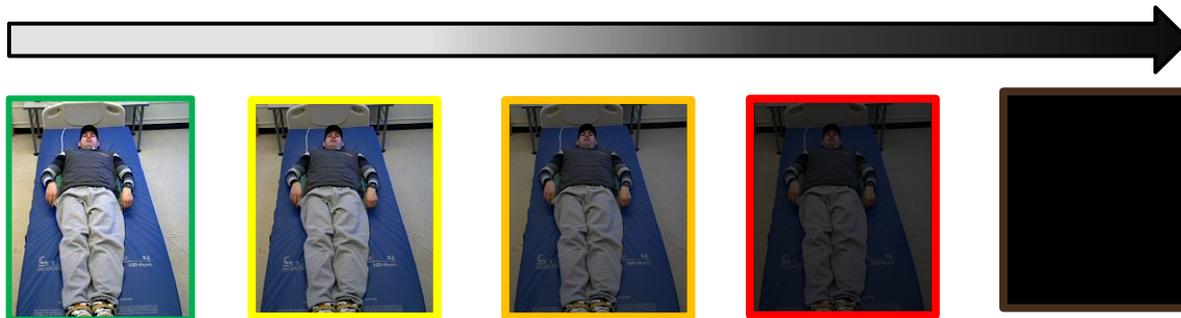


Challenges of ICU Scenarios

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The ICU is a **natural** scenario (unstructured)

Illumination variations

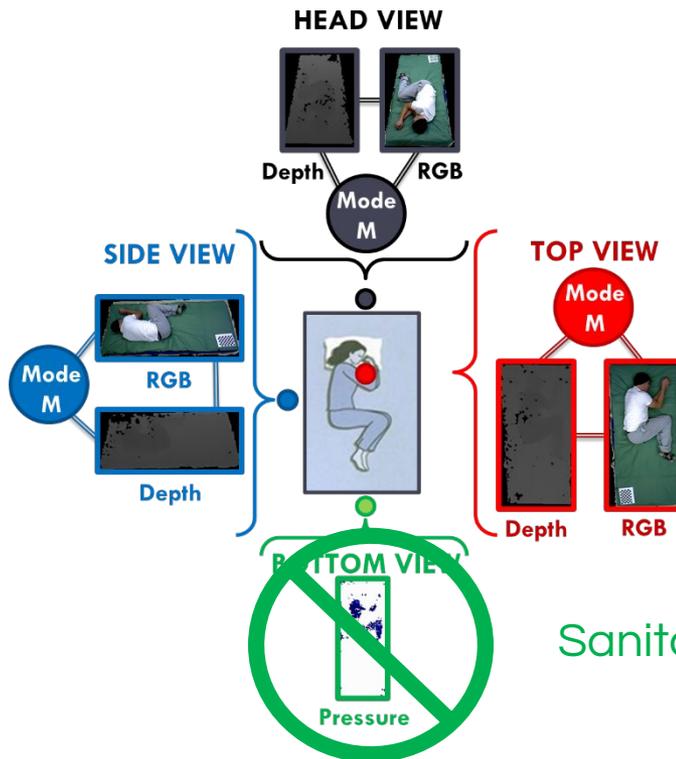


Occlusions (blankets)



The Eye-CU System

Collect multimodal data from multiple views



- Three modalities M
- Three Views V
- Twelve Poses L
- Twelve Scenes C
- Optimized Solution for w_m

Sanitation and Deployment

Multimodal Multiview Data

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Symbol	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
POSE	Fetal L	Fetal R	Log L	Log R	Yearner L	Yearner R	Soldier D	Soldier U	Faller D	Faller U
RGB (R): Views: <i>t s h</i>										
Depth (D) Views: <i>t s h</i>										
Pressure (P)										
Light	Bright	Medium	Dark	Bright	Medium	Dark	Bright	Medium	Dark	Bright
Occlusion	Clear	Clear	Clear	Blanket	Blanket	Blanket	Pillow	Pillow	Pillow	Blanket Pillow

Data point: $\chi_k = \{f_R, f_D, f_P\}$

Histogram of Oriented Gradients
(HOG) $\rightarrow f_R - 8424$

Moments up to 3rd order (gMOM)

$f_D - 360$ elements

$f_P - 360$ elements

Multimodal Trusted Score Computation

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cc-LS Setup

$$\begin{aligned} & \text{minimize}_{\mathbf{w}} \frac{1}{2} \|\mathbf{A}\mathbf{w} - \mathbf{b}\|_2^2 \\ & \text{subject to} \quad \mathbf{1}^T \mathbf{w} = 1 \\ & \quad \quad \quad 0 \leq w_m \leq 1, m = 1, \dots, M \end{aligned}$$

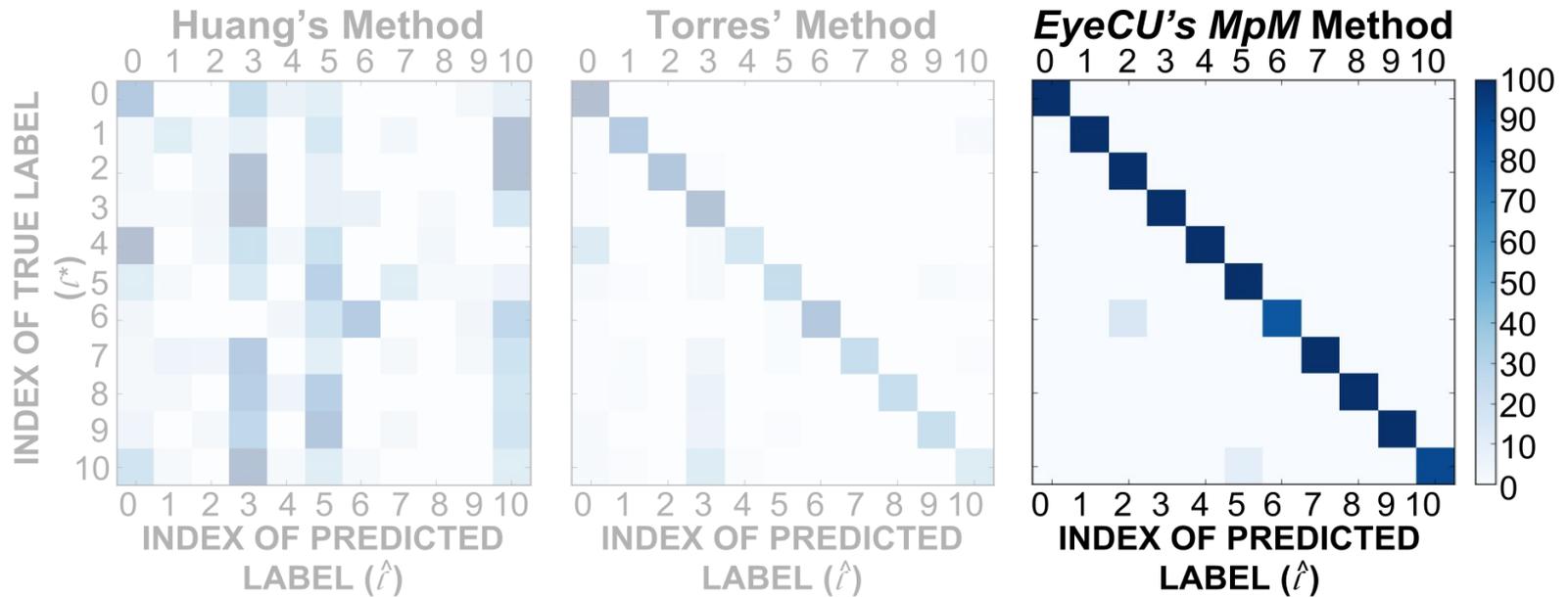
Find the index \hat{l} of the estimated pose label $Z_{\hat{l}}$:

$$\hat{l} = \arg \max_{l \in L} (S_k^c) = \arg \max_{l \in L} \sum_{m=1}^M (w_{\mathcal{N}_m}^c \{\text{CLF}(f_m)\}_L^c)$$

For details please visit - Poster **#340**

Performance of Eye-CU (cc-LS)

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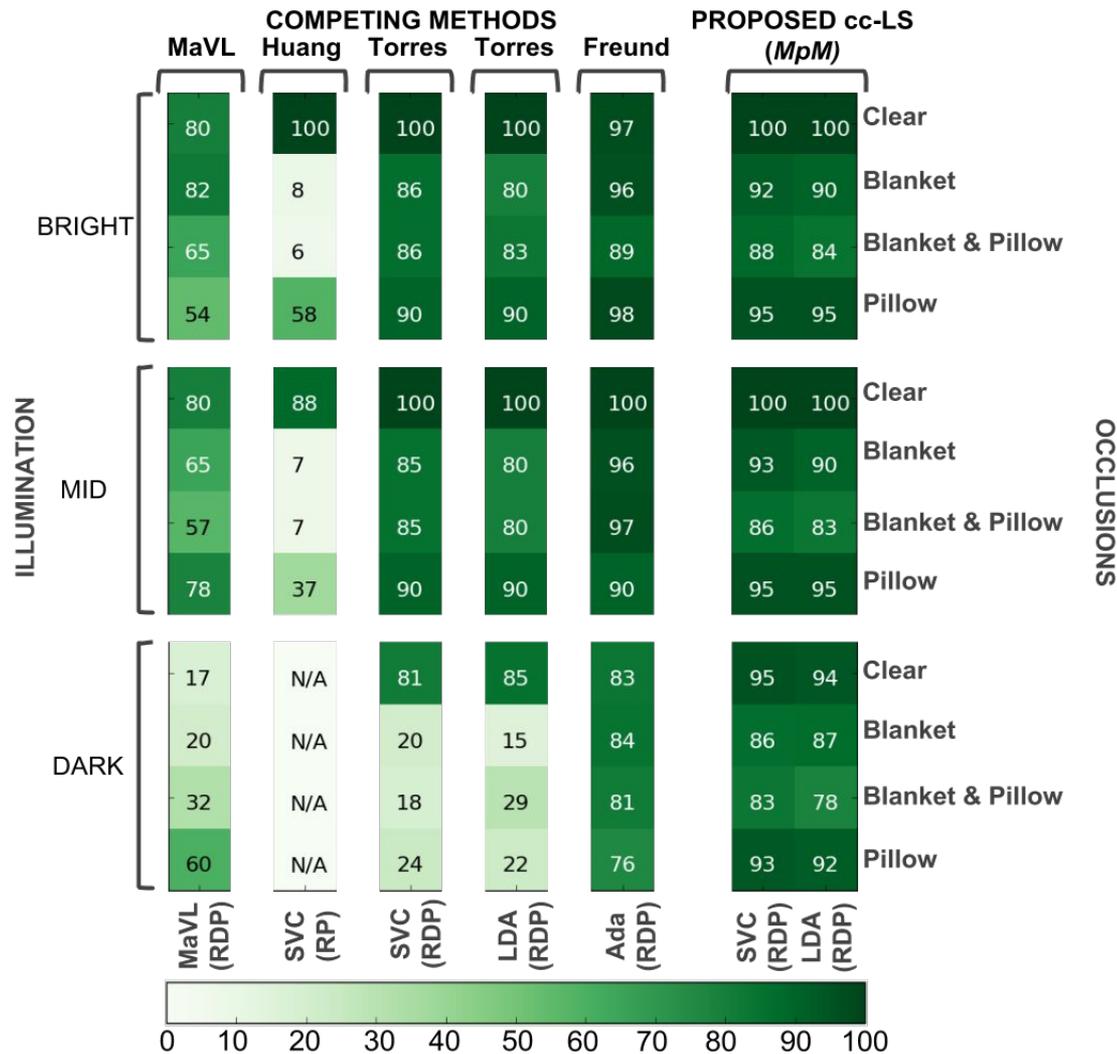


Dim + Occluded Scene



Competing Methods vs cc-LS – Single View

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Conclusion

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1. Evaluation of **existing** methods and unimodal approaches
 - Yang et al. – not suitable
 - Shotton et al. – not suitable
 - Huang et al. – suitable for **ideal** scenarios **ONLY!**
 - Torres et al. (ICVS 2015) – expensive and requires a pressure mat

2. **Eye-CU Systems + cc-LS** is **promising**
 - RGB, Depth, Pressure, and View contributions based on a cost minimization
 - Improvement over existing methods
 - Robustness to illumination, sensor failures, and occlusions (Multiview)
 - Independent of pressure (with minor drop)
 - Simple and can run on arm processor (~10-15fps)

3. May enable **automated** temporal **analysis** of ICU patients
 - Sleep Hygiene
 - Pressure Ulcers

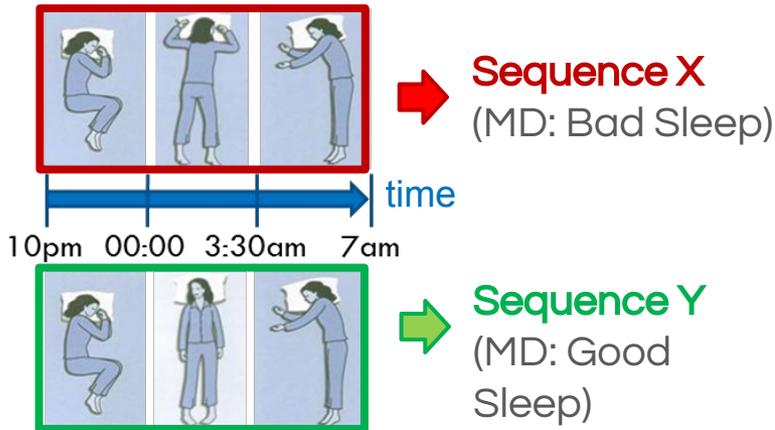
Current Clinical Studies + Temporal Analysis

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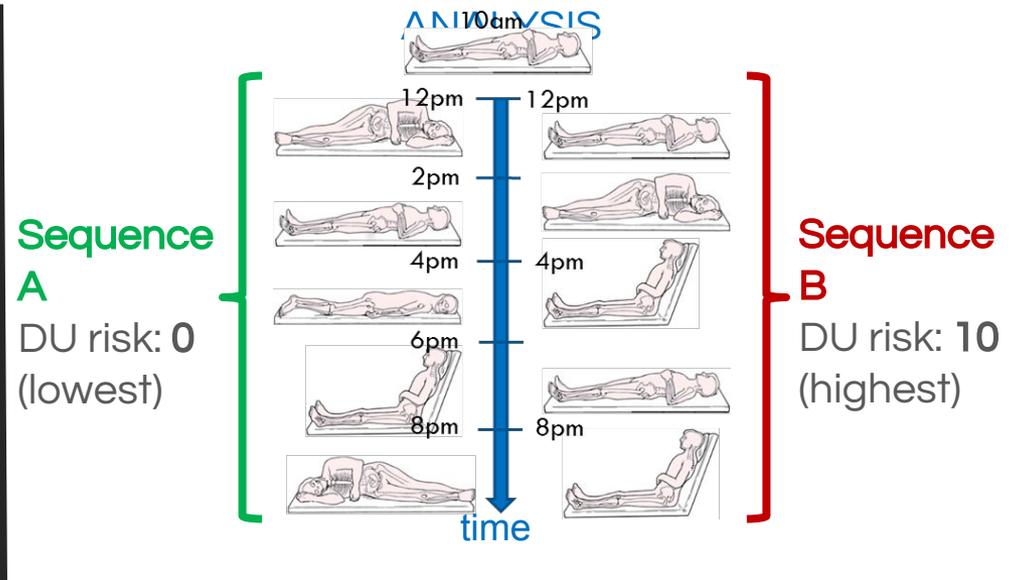
Automated Analysis of Sleep Hygiene and DU Incidence/Prevention

- Non-intrusive **automated** data collection and analysis
- Incidence & risk evaluation from **evidence** (measurements vs observations)
- **Individualize** therapies using quantifiable data
- Deep Features → Improved performance in dark scenarios

SLEEP DISORDER ANALYSIS



DECUBITUS ULCERATION ANALYSIS





YOU!
Q & A

#D17

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