Intelligent Non-invasive Pain Assessment towards Frailty Prevention in Communication-Impaired Populations

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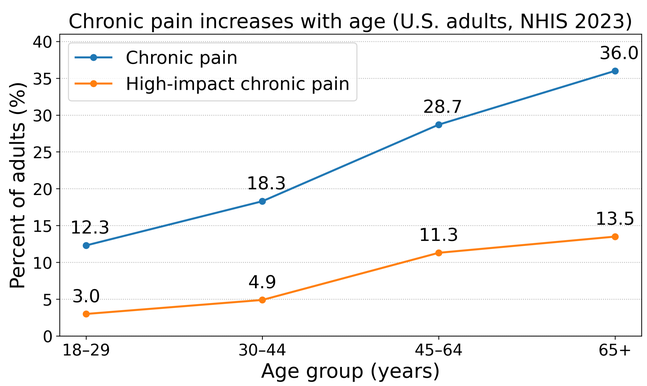
Background

- Persistent pain is associated with **twice the risk** of developing frailty
- **36.0%** of adults ≥65 y.o. report chronic pain (CP); **13.5%** high-impact chronic pain
- Among nearly **1.4 million** long-stay nursing home residents with persistent pain, **6.4%** receive no analgesics; **>30%** receive no scheduled analgesics
- **Communication barrier** (e.g., Alzheimer's Disease and Related Dementia) is one of the most significant sources of under-treatment of pain

Objectives

Timely detection of unexpressed pain and prevention of frailty

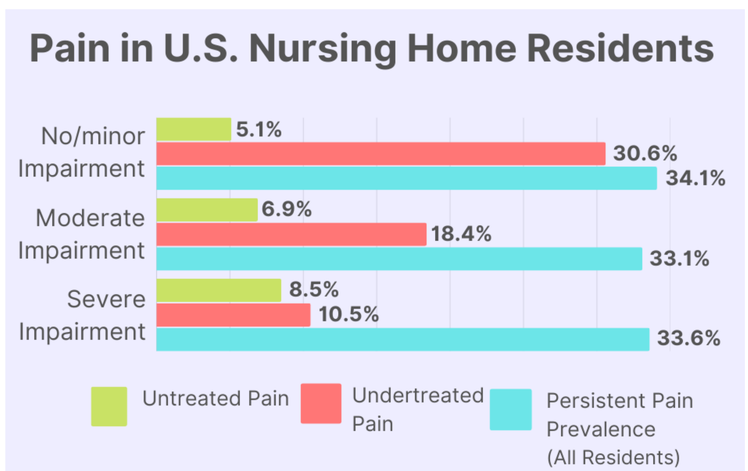
- **Non-invasive, objective sensing:** achieve interpretable and intelligent pain assessment
- **Resilience quantification**: measure reactivity, recovery dynamics, and baseline drift of physiological signals across persistent or intermittent pain among different subjects
- **Frailty-aware modeling**: build pain assessment models leveraging pain history and robust to individual baseline variability
- **Dataset**: collect pain data from **older adults with chronic conditions,** as they are more similar to non-communicative people



Attributes / Data Names	Participants	Older adults included	Wrist Wearable Physiology	Chronic/Clinical Cohort	Stimuli/Pain Types
Our Dataset	18 young (healthy) + 7 older	✅	✅	✅	Electrical
PainMonit	49 (healthy)	–	✅	–	Heat
PhysioPain	99	–	✅	✅	Heat/Clinical
EmoPain	12 healthy + 18 CP	–	–	✅	Clinical
BioVid	90 (healthy)	–	–	–	Heat
X-ITE Pain Database	134 (healthy)	–	–	–	Heat & Electrical
MIntPAIN	20 (healthy)	–	–	–	Electrical

Multimodal Pain Datasets Comparison

Data Collection in the Nursing Home



Methods

- Collect pain data from 25 subjects (7 older adults, 18 young)
- Investigate the recovery dynamics of biomarkers from pain by looking into the correlation between physiological features (e.g., heart rate variability) and temporal features such as accumulated recent pain
- Build pain assessment model from collected data that leverages pain history, personal health conditions, and physiology reserve. Test the model on unseen subjects to evaluate its applicability in the wild

Preliminary Results

- Five-class (from no pain to severe pain) pain classification accuracy can reach 41% (comparable to that of nurses) using transformer and de-identified video modality
- Some clinical features, e.g., heart-rate-variability, show slower recovery as pain accumulates, implying the need for physiology reserve modeling to aid pain assessment
- Subject variability has a significant impact on model performance and is likely the main real-world deployment barrier

Future Work

- Improve the modeling of pain history and physiological reserve, and borrow ideas from stress detection for pain detection
- Collect data from more subjects for more convincing analysis results, especially from old adults with chronic conditions and challenged communicative ability

References

1) Du, X., Safarzadeh, M., Zhu, M., Prasad, S., Das, S., & Chung, J. An Explainable Transformer Model for Pain Intensity Assessment Using Multi-Modal Facial Sequential Images. Available at SSRN 5201152.
2) Lucas, J. W., & Sohi, I. (2024). Chronic pain and high-impact chronic pain in US adults, 2023.