Painometry: Wearable and Objective Quantification System for Acute Postoperative Pain

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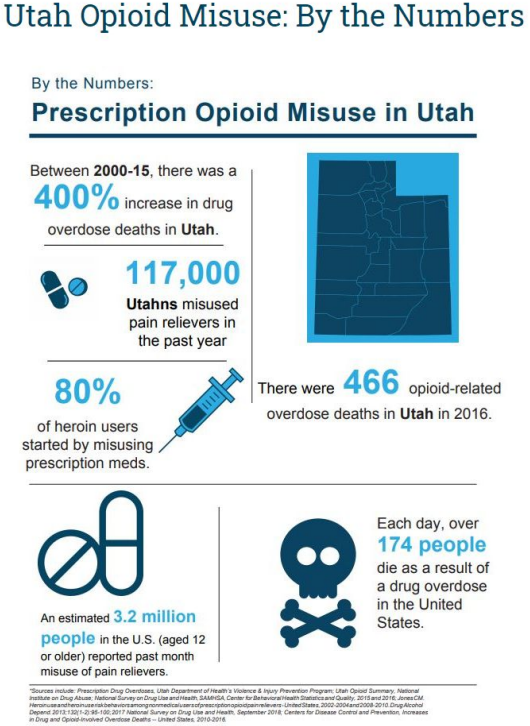
Motivation

The United States has faced an opioid epidemic.

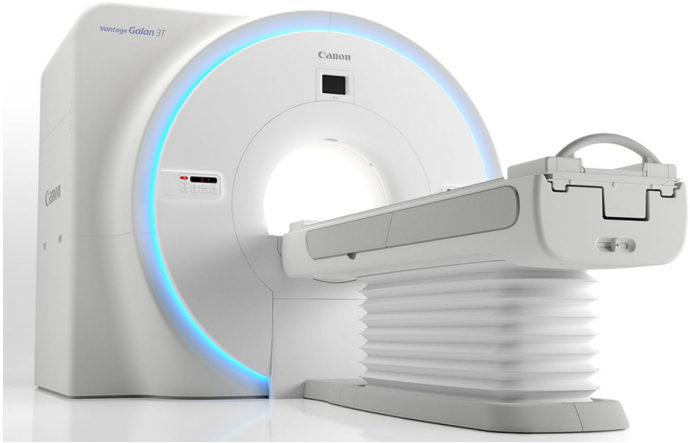
- 40,000 lives lost annually
- 50 million surgeries, 70% opioid prescriptions
- 25% misuse, 10% addiction, 5% heroin
- 80% heroin has opioid misuse previously



Motivation

Current pain management methods:

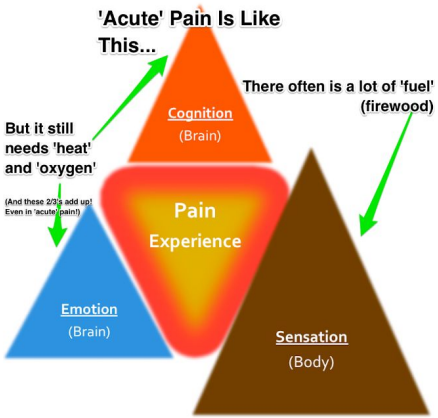
- fMRI
- Invasive nervous sensor
- Self-reporting
  - Subject to cognitive load and emotion
  - Bias from suggestion
  - Limit in availability

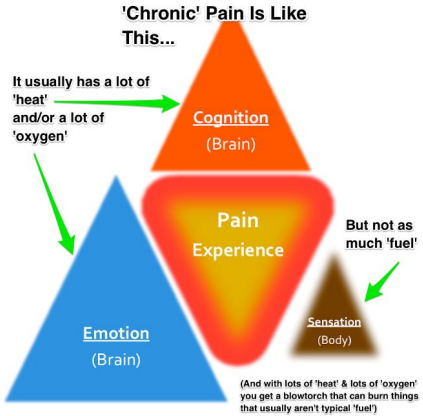


Background information

Some physiology about pain and opioid misuse

- Balance is the key
- Acute vs chronic pain
- Overdose vs underdose





Problem Formulation

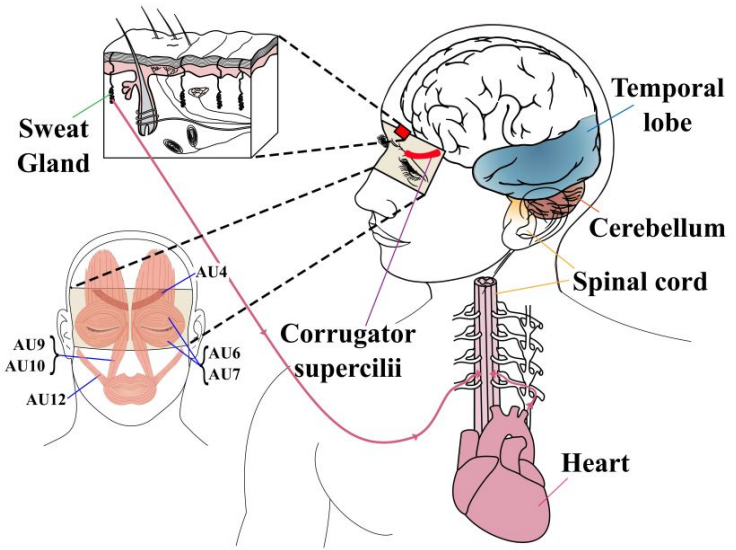
Goal of the project

- Wearable
- No human involvement
- Quantifiable and objective
- Non-invasive

Problem Formulation

What we rely on

- ANS(autonomous nervous system)
- hypothalamus and limbic brain
- Facial expression(44 AUs)
- EEG, GSR, SIP, PPG



System Development

- Sensitive / high resolution muscle activity sensing
- Reliable / Safe System
- Highly Accurate / Lightweight

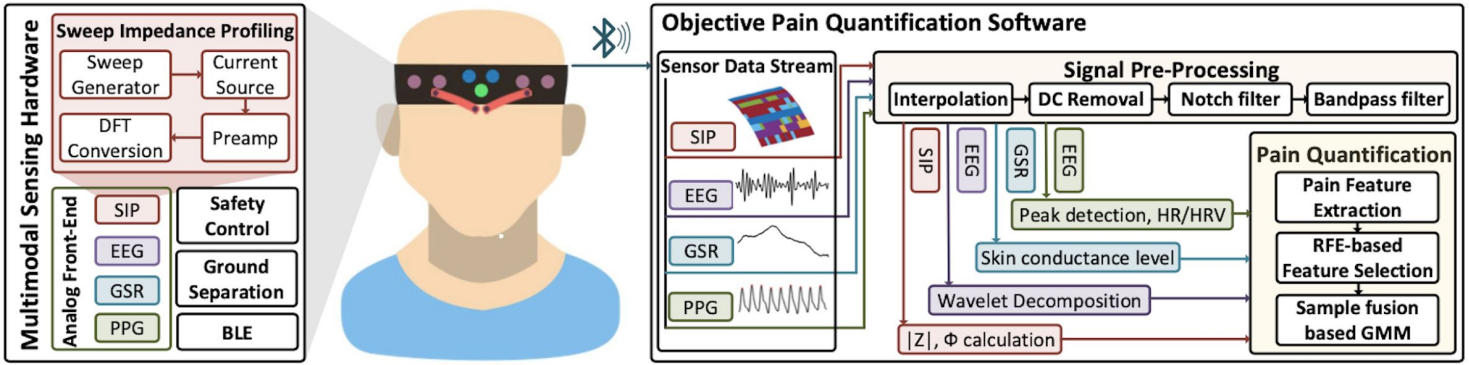


Figure 3: Painometry System Overview. Sensing data collected with multimodal sensing hardware *(Left)* and streamed via Bluetooth to software on host device *(Right)* that process data stream, extract pain features, and quantify pain level.

Sensitive / High Resolution

- Traditionally, EMG used
- Crosstalk noise, nearby muscle activity
- Use SIP, measures impedance

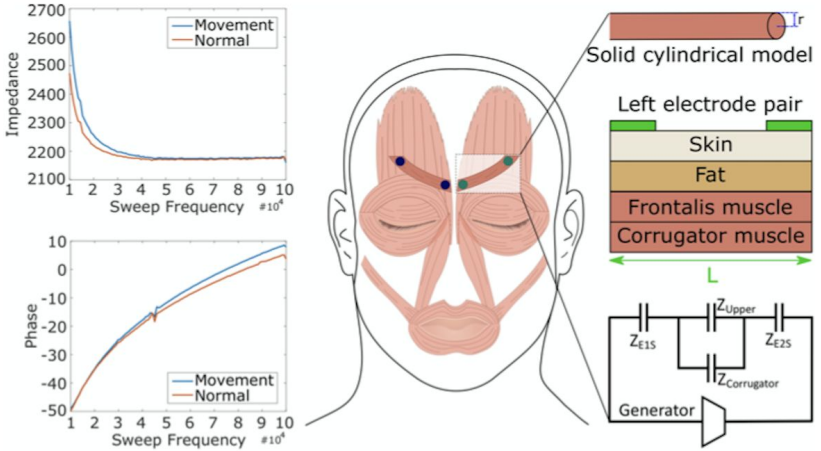


Figure 4: SIP sensors over corrugator supercilii and the corresponding circuit.

Reliable and Safe

- Many sensors, very small hardware
- Crosstalk interference
- Active sensors (GSR, SIP)

Figure 7: Sensor placements in various Painometry form-factors.

Highly Accurate & Lightweight

- Pain is subjective
- No universal set / existing quantifiable pain
- Recursive feature elimination to learn

Evaluation

- Reliability / safety of experimental protocol
- Performance of pain quantification pipeline
- User experience

Evaluation: Experimental Protocol

- Goals:
  - Distinguishable pain levels
  - Avoid short term pain tolerance
  - Safety of experiment
- Pressure Pain Device
  - Pressure, thermal, cold pain
  - Compressed air, piston
  - Clear and distinct pain
  - 3 levels given, pseudorandom order

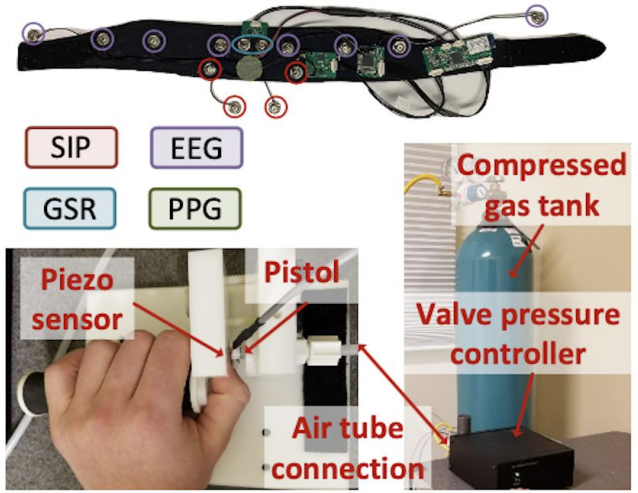


Figure 9: Painometry headband form-factor and pain-inducing experiment setup

Evaluation: Performance

- Accuracy, precision, recall
- Each sensor in isolation
- Leave one out cross validation
  - 22/23 to train, 23rd test
- SIP has a high impact --->
- Power considerations
  - 292.1 mW active
  - 56.8 mW idle
  - 500 - mAh : 5.6 hours active state

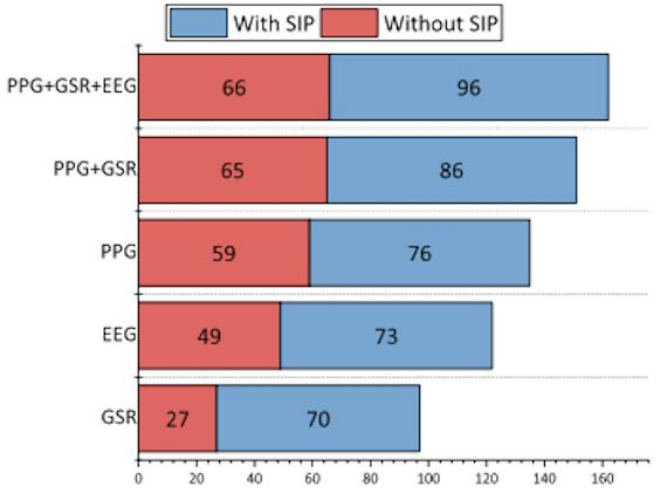


Figure 13: Impact of sensor combinations

Evaluation: User Experience

- Difficult to quantify pain
- Willingness to wear ~ 15-30 min

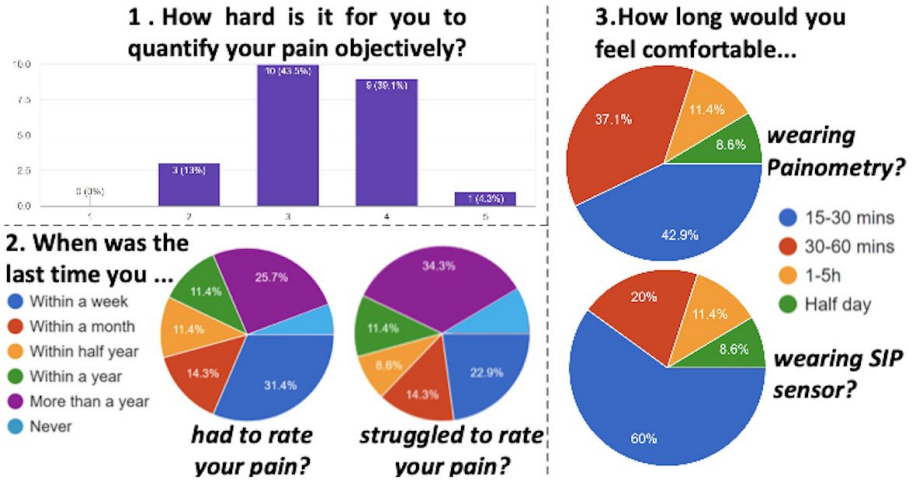


Figure 19: User study results

Your Insight

- Problem very well defined
- Is objective pain a good measurement?
- Users’ willingness to wear a device

Your Insight

Probably not easy to commercialize

- Inefficient market with negative social externality
- Might be difficult to find pusher