Pain Detection of Prenatal Infants

**Sponsor:** WSU Coug Health Lab

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**BACKGROUND**

Prematurely born infants are incapable of communicating pain, making pain detection difficult. Especially since long exposure of high amounts of pain can permanently damage the infant's growth and development. Current systems for monitoring and recording pain still rely on primitive pencil and paper tests; which are time consuming, subjective, and potentially inaccurate.

The goal of this project is to develop a system capable of automating these tasks and communicating the infant's pain quickly and effectively. By using ongoing research developed by WSU's Health Lab, key features of the infant can be monitored in order to detect if the infant is in pain. This included monitoring ECG data, facial flex data, and hand flex data. With these key features, a pain index is calculated by running the data through a linear network which can quickly translate these inputs into a simple pain score ranging between 1 and 10.

**OBJECTIVE**

Create a fully functional infant pain monitoring system that takes input from the heart rate sensor, finger flex sensor, and facial sensor to determine the current pain level of an infant. The system will learn based on how infants react to predefined pain indicators to determine the actual level of pain an infant is in.

**HARDWARE**

The wireless protocol is to be low powered and send data in real time as it is received by the facial sensor. This is an integral part of the system as it keeps wires away from the infant's face.

![Figure 1 - 2.4GHz 0.7cm² Wireless Patch Antenna](image)

The antenna needs to be 3-D printed with a frequency of 2.4 GHz. Along with that, another major need is to create the antenna as small as possible (around < 0.5 cm a side). The goal is to create a micro-strip antenna working at 2.4 GHz and then reduce the size of the antenna to the infant's face.

**ALGORITHMS**

The data processing hub (STM32F407) will be responsible for communicating with all other hardware in the system, being the ECG, CC2650, and the visual indicator output. When the STM32F407 receives all three inputs (ECG, facial sensor data, and hand flex sensor data), it transforms the ECG data from time domain to frequency domain and extracts key features for processing (power spectral density and frequency ratios). With the key features from the ECG extracted and the other data from the sensors collected, the data is then ready to input into a linear network to translate these features into an output pain index. The linear network is trained beforehand and executes a static translation of data.

**DIAGRAM**

**FUTURE PLANS**

- Investigate better machine learning algorithms so better adapt to accommodate infants with different pain thresholds
- Implement the patch antenna (remove dependency on blood-tontooth)
- Replace FFT with Lomb-Scargle algorithm (Better accuracy with high frequencies)

**BROADER IMPACT**

- The wireless network will operate at the 2.4GHz band, so it should not cause interference with any other devices.
- Will help medical professionals easily monitor infant pain levels in real time.

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**Figure 3 - ECG Translation Outputs**

**Figure 2 - Spectrum Analyzer Sweep with 0 dBm input**