Quad Rat Vitals Monitor

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Abstract

The design and construction of a rat vitals monitoring system is essential for simultaneously monitoring multiple anesthetized rats. Our client currently runs PET scans on four rats simultaneously, and the scans can last up to two hours. During the two hour scans, the rats are under anesthesia and doses of the anesthesia medications must be adjusted based on the rats' vitals. The client desires to have an accurate, reliable, and easy to use rat vital monitoring device to aid in this process. The current design for this monitoring device includes force-sensing resistors (FSR) for monitoring breathing rate, thermistors to monitor rectal temperatures, and pulse oximeters to monitor SpO2 levels and heart rates. The design also includes an easy-to-read graphical user interface (GUI) that displays live traces of the vitals as well as the current value of those vitals in the form of heart rate, blood oxygen saturation, temperature, and breathing rate.

Motivation

Our client's research required him to monitor vitals of four rats individually. The laboratory assistants must be informed in a timely manner if any of the four vitals enter critical ranges so adjustments to the anesthesia can be made.

Existing Devices

MouseOx, produced by Starr Life Science™ and the Nellcor N-100
- Monitor SpO_2 levels, heart rate, and breathing rate
- Not capable of monitoring multiple rats
- Four separate units not cost effective

Figure 1. MouseOx: Image taken from http://www.starrlifesciences.com/images/products/mouse_analog.png

Previous Work

Figure 2. Functioning probe on rat under anesthesia (left)

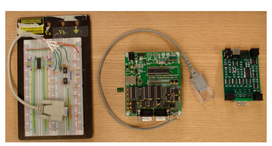


Figure 3. Progression of pulse oximeter circuit development. Bread board prototype containing photoplethysmograph (left), prototype wire-wrap board (middle), and final printed circuit board (right).

Final Design

Hardware

- Produced 4 working boards
- Boards contain input for a force sensing resistor, pulse oximeter and thermistor
- Data output via USB connection
- Operates on a 7.5 v power supply
- Small in size: (3x2x1) inches

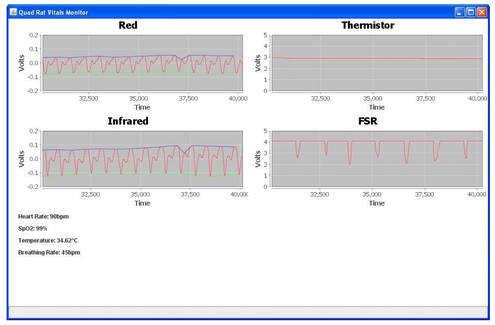


Figure 6. Graphical user interface of final product made in Java. Graphs of Red, Infrared, Thermistor and FSR are all displayed along with values of heart rate, SpO2, temperature and breathing rate.

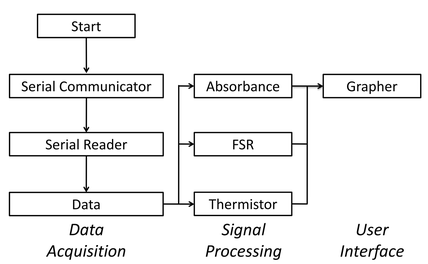


Figure 5. Flow chart of the 3 stages of the board. Starts with data acquisition, continues into signal processing and finally the data is displayed through the user interface.

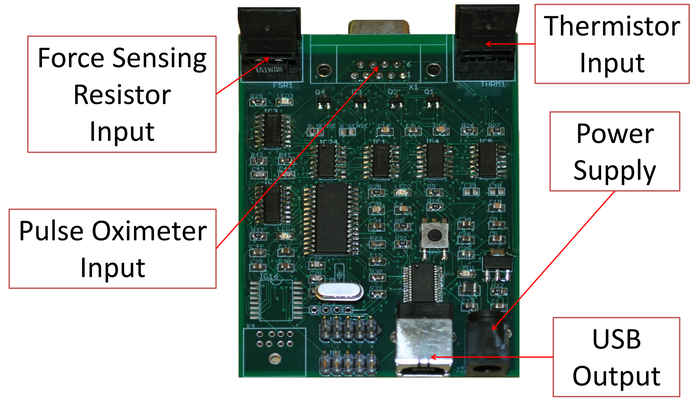


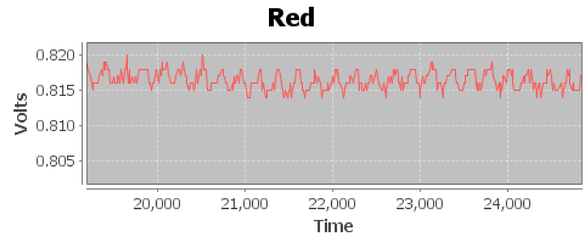
Figure 7. The board itself containing the force sensing resistor (FSR), pulse oximeter input, and thermistor input along the top row. Power supply and USB output are at the bottom. The board also contains a reset button in the middle

Interface

- Written in Java, an open source program language
- Handles data acquisition, real-time signal processing and user interface
- Signal processing includes filtering and peak detection
- Acquires and processes data simultaneously
- Framework extensible
- Fully documentable data collection
- Uses RXTX for serial communication
- JFreeChart allows for graphic displays and dynamic control

Testing

- Heart rate measurements on a rat under anesthesia
- Sampling frequency at 90 Hz
- Graph indicates ~300 beats/minute
- Wanted to test a professional pulse oximeter probe which worked
- Graph below includes a 5th order bandpass filter



Budget

Fall 2010
- Mouser – Circuit Components – $97.29
- Digi-Key – Circuit Components – $61.00

Spring 2010
- Mouser – Circuit Components – $26.40
- Digi-Key – Circuit Components – $371.14
- PCB Express – Circuit Boards – $548.00
- RadioShack – Power Supply – $30.55

Fall 2008- Fall 2009
- Client – Lenovo Laptop – $660.00
- Misc. hardware Components: - $409.00

Total: $2,203.38

Future Work

- Design system controller
- Improve accuracy of signal processing algorithms
- Implement data saving and history graphs
- Expand user software for four rats
- Design housing device
- Conduct full system test during client's research
- Incorporate wireless capabilities

Acknowledgments:

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References:

Webster, J. G., Design of Pulse Oximeters. IOP Publishing Ltd 1997.
Starr Life Sciences™ Corp. © 2009
Nellcor Puritan Bennett LLC. © 2009