Esophageal Probe

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LEGACY HEALTH

TZ Medical
Sparked by your ideas

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Background

Project sponsor Nathan Kemalyan is a burn surgeon with Legacy Health. During surgery, it is necessary to monitor the patient's vital signs continuously. Normally, the devices used to monitor vital signs require direct contact with the patient's skin in order to collect measurements. In burn cases, however, the majority of the patient's skin is either compromised by burns or is required for harvesting grafts necessary in the surgery. Due to this, the locations available for monitoring can be very limited and numerous complications can arise because of ill suited measurement equipment. These complications can often be magnified by the need to transport these individuals from place to place. These problems could be avoided if the measurement devices were adapted and incorporated into a single device which could be deployed within the patient's esophagus.

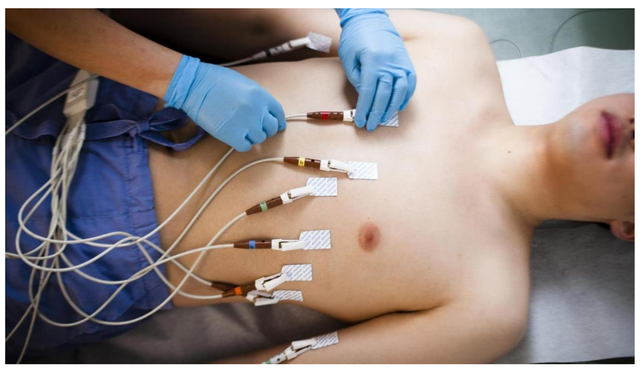

Figure 1. Electrocardiography probes being applied to a patient.

Objectives

Design an esophageal probe which measures vital signs including core body temperature, blood oxygen saturation, and electrocardiography. The probe's performance should be reliable for at least 72 hours of continuous use and it should have a shelf life of more than 18 months.

Current Design

Design

The current esophageal probe prototype, shown in the Fig.5, contains three measuring devices: A temperature sensor, a pulse oximeter sensor, and electrocardiography (EKG) electrodes. All of these sensors allow for the measurement of the core body temperature, the amount of oxygenated hemoglobin in the blood, and the heart rate. The current probe is about 50 cm in length using an 18 French (6mm diameter) tube.

The three metal EKG leads reach 34 cm down the throat from the upper incisors. This places the leads in close proximity to the heart for a clear measurement of its electrical impulses. The three leads can be hooked up to the current patient monitors used by Legacy Health.

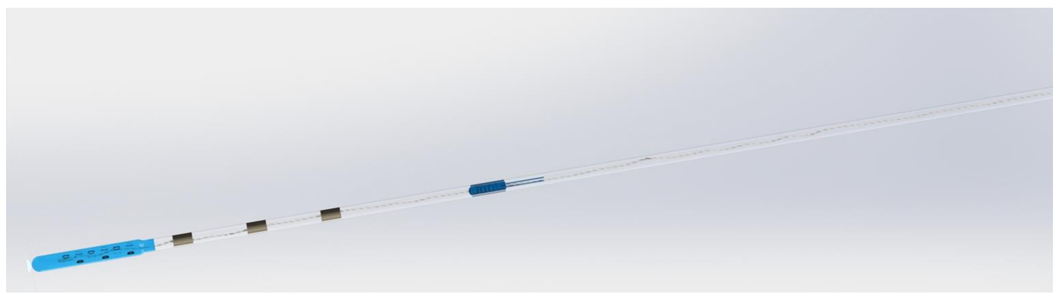

Figure 2. SolidWorks model of the complete probe assembly.

The pulse oximeter reaches about 25 cm down the throat from the upper incisors, placing it in direct contact with smooth esophageal tissue. This sensor was created using red and infrared LEDs, and a photo pin diode. Oxygenated hemoglobin reflects red light and absorbs infrared light; Deoxygenated hemoglobin absorbs red light and reflects infrared light. The photo pin diode measures the magnitude of the red and infrared light that is reflected by the blood and produces an electrical current for each. The probe connects to an Arduino control circuit where the currents are converted to a voltage measured by an analog to digital converter. This system then connects to a computer which calculates the ratio between the voltage values of the red and infrared light. This ratio is used to calculate the percent oxygen absorption of the blood, which is displayed in real time along with a plethysmograph.

The temperature probe is a thermocouple that sits at the tip of the probe housing. It measures the core body temperature of the patient during surgery. It connects to the patient monitors currently used by Legacy Health.

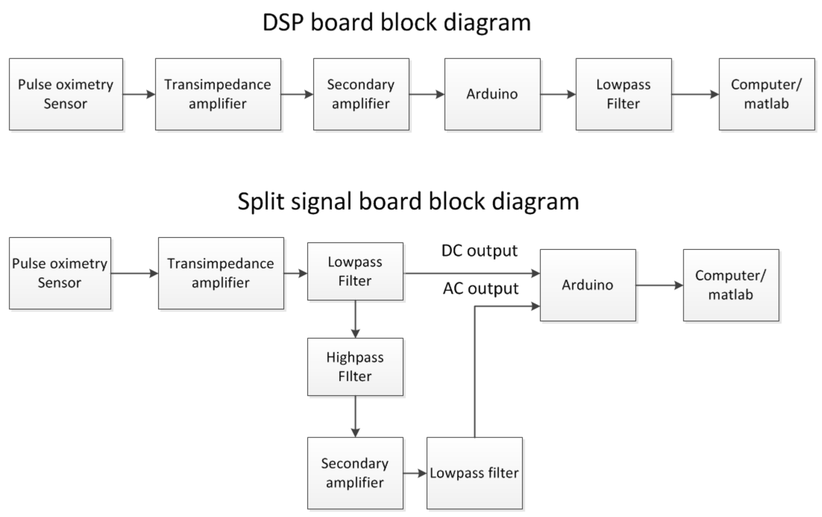

Figure 3. Block diagrams for the DSP and the split signal boards.

Two methods of data processing were pursued in order to determine the most effective way to process the data gathered by the pulse oximeter. The two different diagrams are shown in Fig.3. The split signal board diagram is shows a separation of the DC and AC components of the sensor readings in hardware filters while the DSP board uses FFT in Matlab to separate the DC and AC components. These AC and DC components are used in the blood oxygen equations. The physical boards are seen in Fig.7 and Fig. 8.

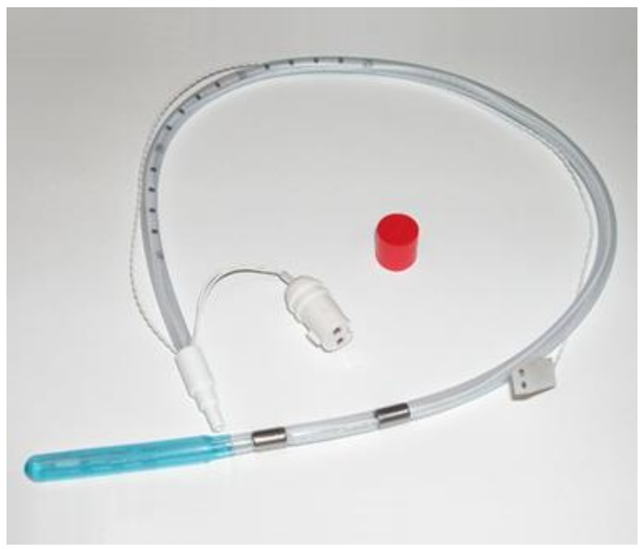

Figure 4. Available heart pacing catheter with a temperature sensor.

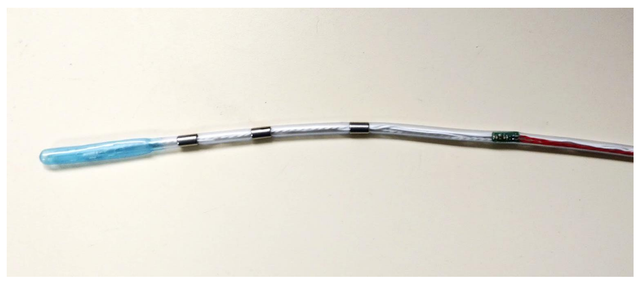

Figure 5. Final probe prototype.

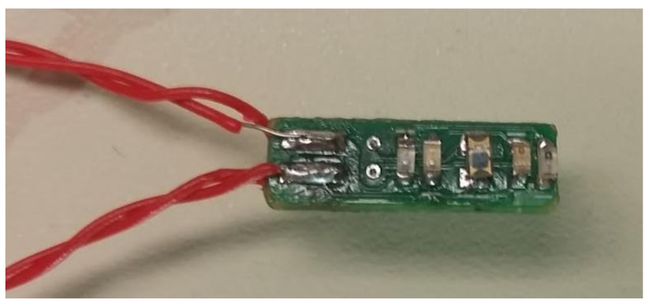

Figure 6. Final SpO2 sensor prototype.

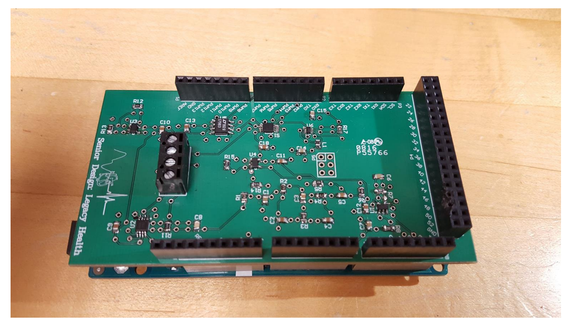

Figure 7. DSP board

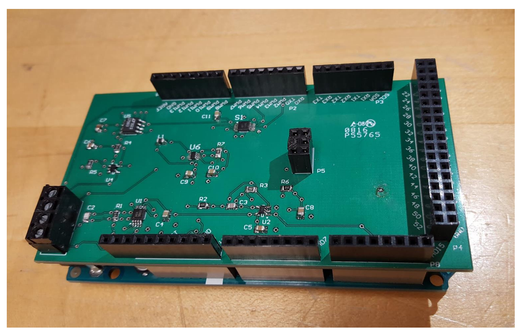

Figure 8. Split signal hardware filter board

Long Term Proposal

Currently the pulse oximetry probe is not able to interface with the patient monitor, but is a future goal. The project may be adopted by TZ Medical for further research and development.

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