Non-Contact Piezoelectric Bed Sensor for Asthma Research

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Introduction

Conventional methods for monitoring asthma status rely on the patient's subjective recall of symptoms along with lung capacity measurements obtained from peak flow meter readings. Many patients improperly use their peak flow meter or record their readings inconsistently. Use of these methods leave lack of reliable quantitative data leaves providers and patients without a good understanding of their asthma status.

Asthma is a disease that involves inflammation of the airway in lungs causing constriction or obstruction. This disease greatly affects the quality of life of patients. Approximately 20 million Americans suffer from Asthma. The annual costs of asthma in the U.S. is estimated to be 18 billion dollars. Asthma currently accounts for 25% of ER visits and 10 million outpatient visits each year in the United States.

The objective of this project is to develop a research tool to monitor signs and symptoms which may be present in asthmatics at night. Our sensor aims to detect heart rate, respiration rate, and restlessness in order to better quantify asthma status at night.

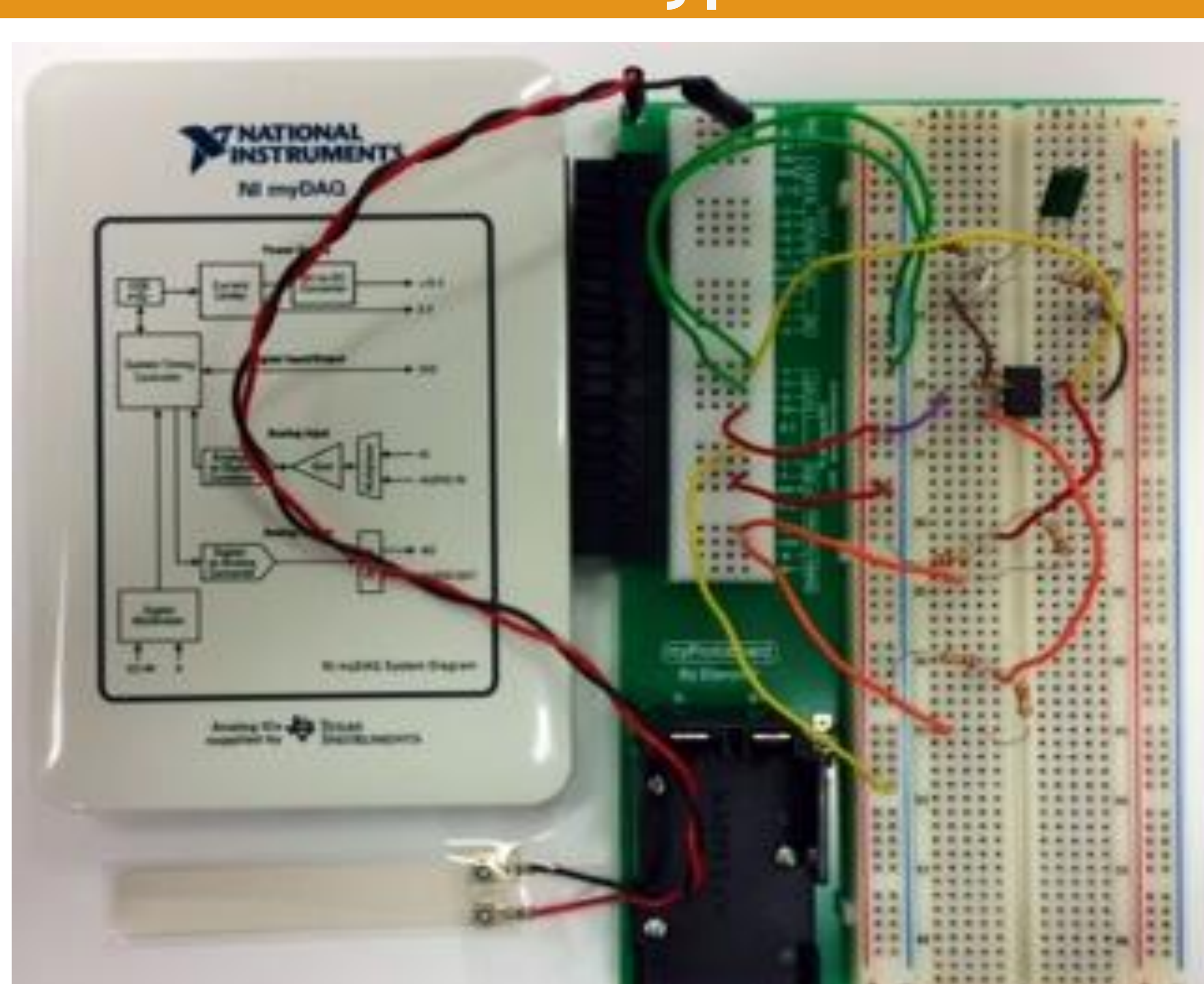
Design Constraints

Due to the sensitive nature of health information and technology in the home setting there were a few constraints that were in place to ensure comfort and adoption of the technology of the patient.

Design Constraints:

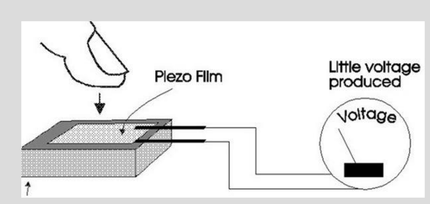
- Patient does not need to actively interact with device
- Non-contact Sensor
- Unobtrusive
- No Audio/Video Recording
- Low Cost

Prototype



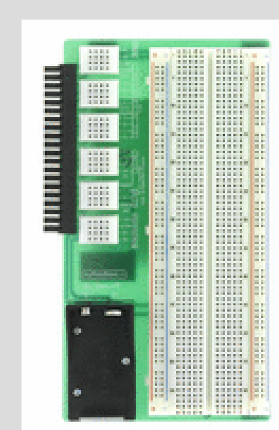
Methods

Piezoelectric Film



Piezoelectric strips generate a voltage when they are subject to dynamic changes in pressure. This thin sensor is placed under the thorax of the subject sleeping on a bed. The sensor bends due to the changes in pressure that result from chest movements and outputs a proportional voltage.

Signal Conditioning



The myProtoBoard for NI myDAQ harbors the signal conditioning circuit necessary to amplify the measured signals of interest prior to software analysis. The primary mode of signal conditioning is referred to as a charge amplifier and will serve to filter unwanted noise in addition to the amplification. Utilizing this breadboard allows for easy connection to the analog to digital signal converter and access to the myDAQ's voltage supply.

myDAQ

The myDAQ is a data acquisition device fully compatible with the National Instruments products MultiSim and LabVIEW that we are using. This device provides the analog to digital conversion for data acquisition and interface with a PC. It is USB compatible with the equipment we are using for design verification and also has the capability to be used as an ammeter and voltmeter.

LabVIEW

LabVIEW provides a graphical programming environment that allows for signal acquisition, data analysis, and visualization. Much of the signal filtering is performed within the LabVIEW software which allows for easy changes to software design. Frequency filtering was the primary mode of signal analysis for this project due to the well known frequency ranges of heart rate and respiration.

Preliminary Results

The piezoelectric sensor and wires were attached to the bed sheet with tape at the junction of the sensor and wires. This allowed to sensor to flex more freely underneath the subject. Voltage was recorded in LabVIEW using the myDAQ for the entirety of the test period. As the subject breathed and moved there were changes in voltage due to the dynamic changes in pressure. The sensor was positioned underneath the center part of the subject's rib cage (shown in Figure 1).

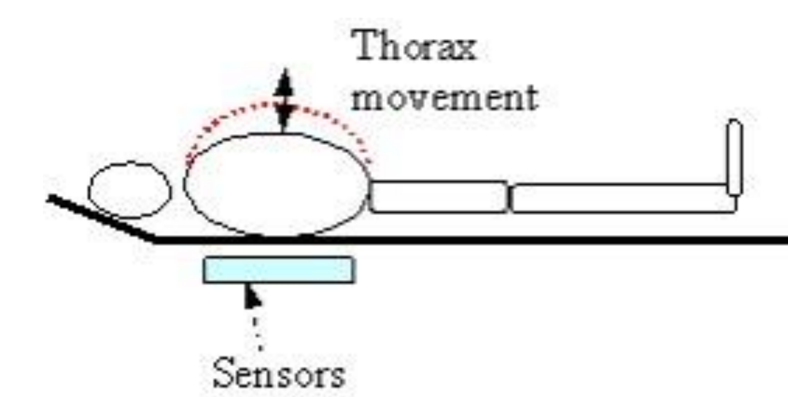


Figure 1. Placement of piezoelectric sensor under patient

Currently, the recorded data has captured both respiration and restlessness of the patient. This data shows a correlation between proven respiration detection equipment (respiration belt) and the piezoelectric signal from the sensor. Figure 2 shows data from a respiration belt (red) and the piezoelectric sensor (white). The figure shows a delay between the two signals which can be attributed to the physical parameters that each one detects.

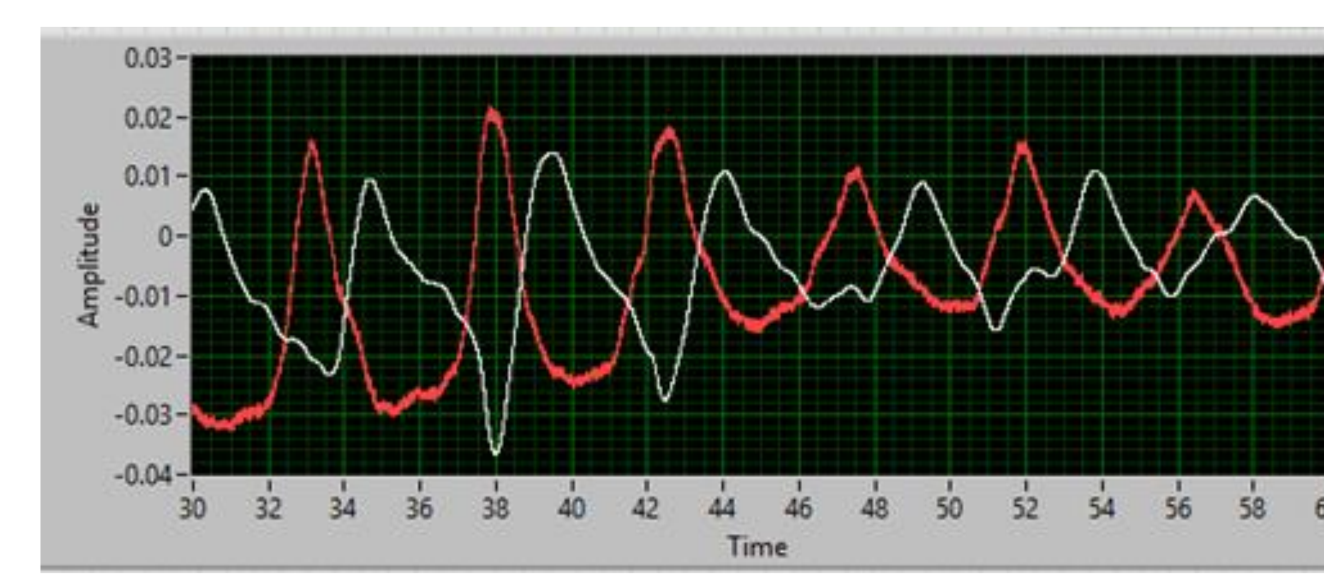


Figure 2. Respiration signals from respiration belt (red) and piezo sensor (white)

Acknowledgements

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References

1. ASTHMA FACTS AND FIGURES. [cited 2014 October 2]; Available from: http://www.aafa.org/display.cfm?id=8&sub=42#cost.
2. Karki, James. “Signal Conditioning Piezoelectric Sensors.” “*Signal Conditioning Piezoelectric Sensors*” (n.d.): n. pag. Texas Instruments, 2000. Web. 27 Nov. 2014.