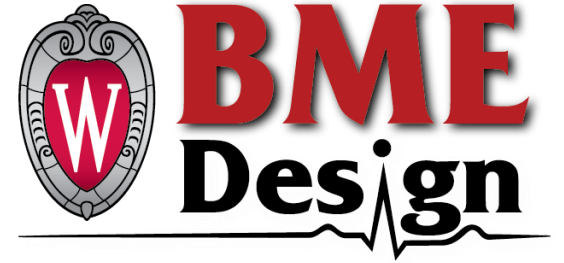




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Continuous monitoring of asthma control

Advisor: Dr. Thomas Yen
Client: Dr. Sameer Mathur

Team members: Lida Acuña Huete
Cassandra Thomas
Jesse Wang

Outline

- Problem Statement
- Client Description
- Design Constraints
- Broader Impact
- Summary of previous semester
- Specific Goals
 - Fabrication
 - Evaluation/Testing
- Documentation
- Budget



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Baseline Asthma Symptoms

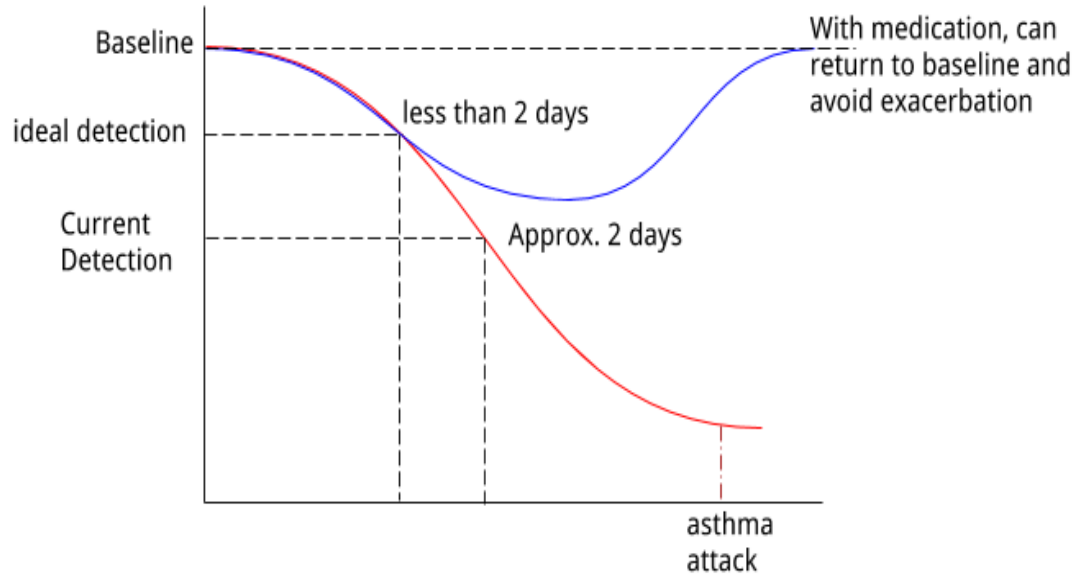


Figure 1. Asthma symptoms vs. detection time

Problem Statement

- Asthma exacerbation
 - Severe attack could be fatal
- Baseline tidal volume
 - 2 days to notice
 - Contact physician
 - Preventative measures, i.e. prednisone¹
- New technology to detect change in asthma symptoms
 - Earlier detection

Design Constraints

- Non-restrictive wires
- Allow for continuous monitoring/transfer information quickly
- Machine Washable
- Size Adjustable

Client Description - Dr. Sameer Mathur



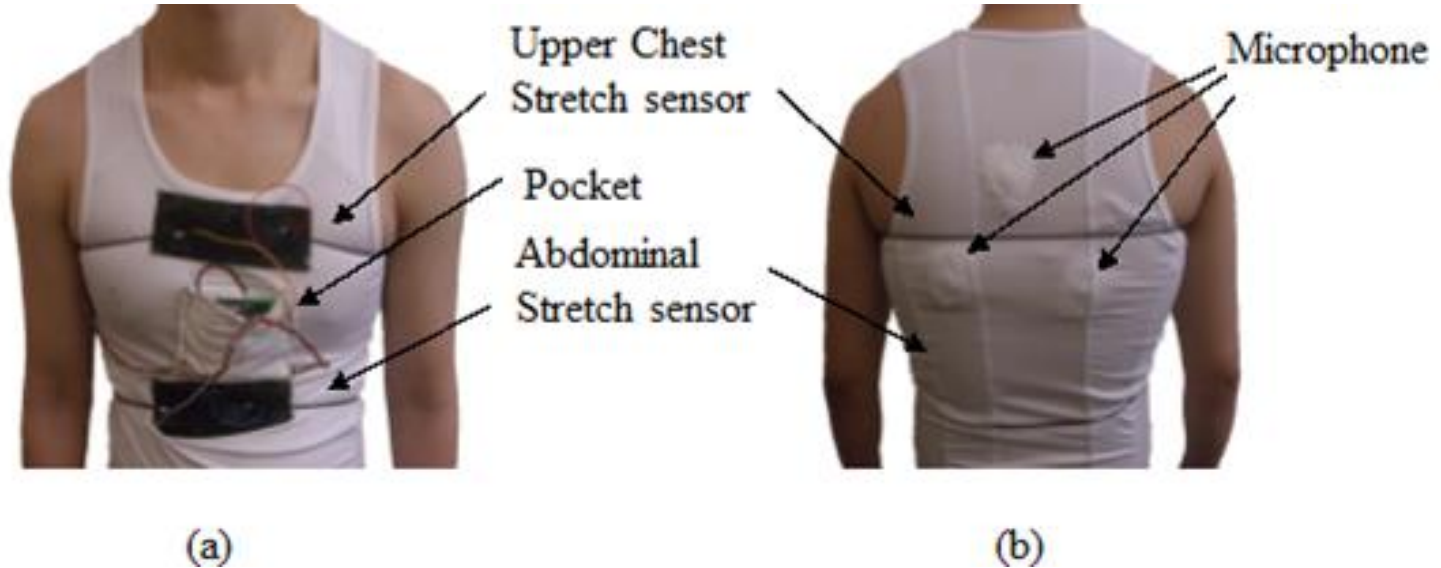
UW Health, "Sameer K. Mathur, MD, PhD", 2016. [Online].
Available: <http://www.uwhealth.org/findadoctor/profile/sameer-k-mathur-md-phd/6825>.

- Affiliated with University of Wisconsin Hospitals & Clinics
- Board certified in Allergy and Immunology
- Research recruitment of adult asthma subjects

Impact

- Allow physicians access to real time data
 - Take AAP² upon the onset of asthma attack
- Continuous monitoring
 - Reduce number of ER visits
 - Quick detection and alert (< 6 hours for treatment)
- Further testing with all ages (include children)

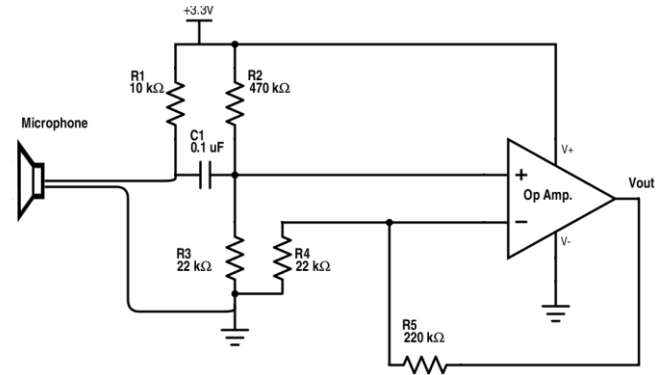
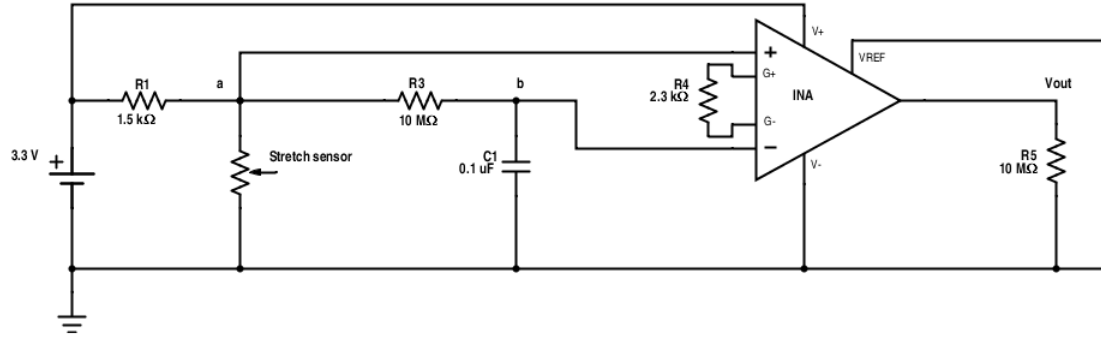
Previous Design and Improvements



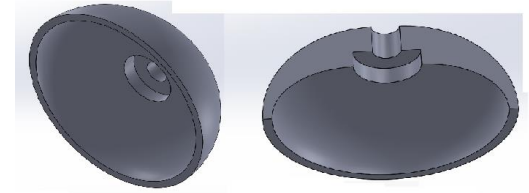
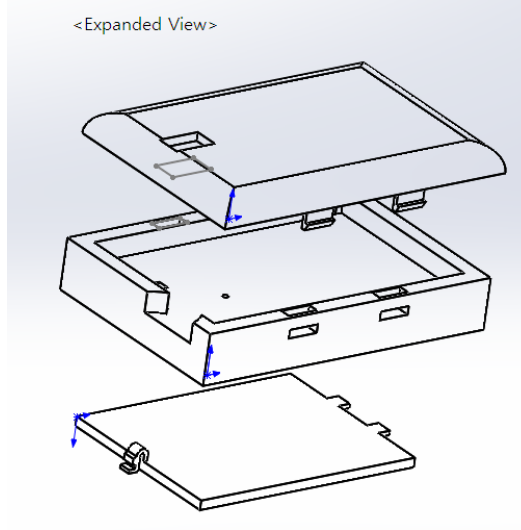
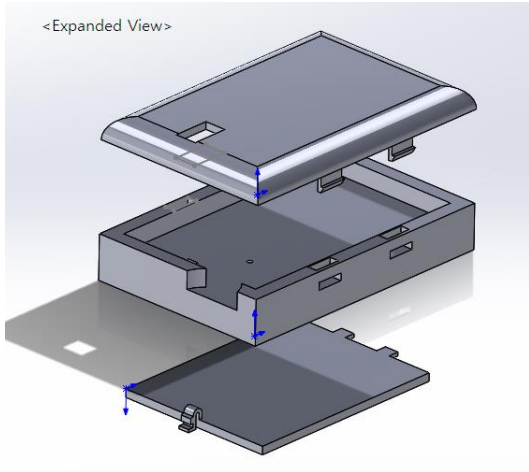
Previous design (a) shows the front side of the shirt, with black boxes holding electrical components whereas (b) shows the placement of the microphones³

Electronic Setup

- Circuit diagram of Microphone and Resistance band connection
- Low pass filter: corner frequency $< 0.167\text{Hz}$



Electronic Housing



- Battery and circuit housing design
- Stethoscope-like housing for microphone.

Goals

- Algorithms detect peak to peak values
 - Calculate tidal volume and respiratory rate
 - Detect changes in volume of 12% or 20%⁵
 - Calibration to individual
- Detection of asthma attack
 - Minimize type I and type II errors
 - Incorporate volume and sound data
- Generate 'gold standard'

Design Improvements

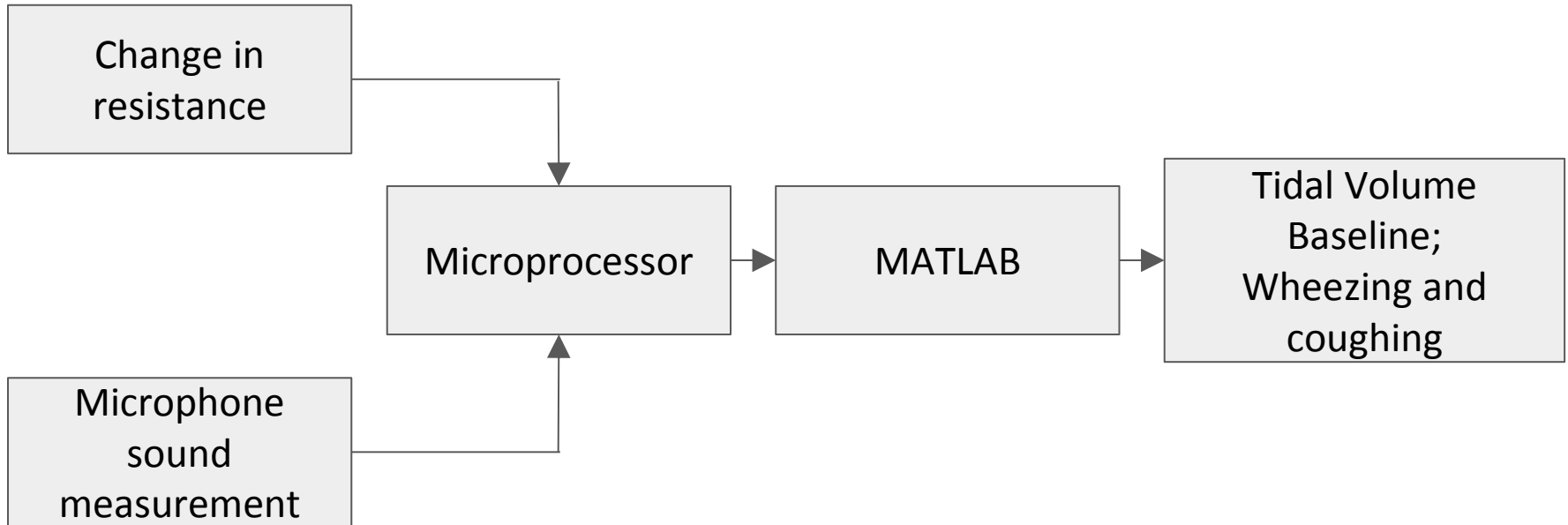
- Wires are detachable
- Additional sensors
- Data is collected via Bluetooth
- Microphone:
 - Cup-like shape to funnel sound

Testing

Two stages:

1. Asthma symptoms
 - a. Arduino collects data
 - b. Matlab analyzes
 - i. Volume Δ 12% or 20% ($p < 0.05$); isolate cough peak
 - c. Create tidal volume graphs; sound data plots
2. In environment
 - a. Induced asthma exacerbation
 - b. Validation of device

Testing Asthma Symptoms



Testing in Environment

- Has been approved, all members are IRB certified
- Can begin as soon as design is validated
- Induce asthma exacerbation
 - Similar to real life
 - Use shirt to monitor for ~1 hour
 - Under medical supervision
- Collect data to view how effective design is

Timeline

- Begin testing for asthma symptoms
 - Make sure graphs are acceptable
- Begin testing on patients currently in client's asthma study
 - Induce asthma exacerbation
 - Record tidal volume baseline and volume Δ
 - Detect coughing and wheezing co-occurrence
- Potential for peer-review

Documentation

Methacholine Challenge - C. Harty (2009)⁶

This SOP describes the responsibilities of the research team members in conducting methacholine challenges to promote adherence to all applicable federal, state, and local laws, policies, and guidelines.

Methacholine testing is performed to measure the severity of bronchial reactivity. Nearly all asthmatics with active disease exhibit narrowing of their airways when they inhale low concentrations of methacholine.

Budget

Order Date	Item	ID	Quantity	Website	Cost
2/1/2016	Electret microphones	668-1389-ND	10	Digikey	\$ 19.89
2/1/2016	Resistive band (1m flexible Stretch Sensor cord)	RB-Ada-34	4	Robotshop	\$ 48.80
2/1/2016	Arduino Bluetooth module	Bluetooth Mate Silver	1	Sparkfun	\$ 24.95
2/1/2016	Microcontroller: Arduino pro mini (3.3V)	DEV-11114	1	Sparkfun	\$ 9.95
2/1/2016	microSD transflash breakout board	BOB-00544	1	Sparkfun	\$ 9.95
2/1/2016	polymer lithium ion battery (2000 mAh)	PRT-08483	1	Sparkfun	\$ 12.95
2/1/2016	FTDI Basic Breakout	DEV-09873	1	Sparkfun	\$ 14.95
2/1/2016	Female Headers	PRT-00115	1	Sparkfun	\$ 1.50
2/1/2016	Break Away Headers - Straight	PRT-00116	1	Sparkfun	\$ 1.50
2/1/2016	Break Away Male Headers - Right Angle	PRT-00553	1	Sparkfun	\$ 1.95
				Total	\$146.39

Budget

To be purchased: 3D-printed microphone case, PCB circuit, elastic bands

Total budget: \$300.00

Acknowledgements

Dr. Sameer Mathur

Dr. Thomas Yen

Dr. John Webster

Keum Sam Chun

Elizabeth Schwantes

References

- [1] "[Prednisone](http://www.drugs.com/monograph/prednisone.html)". *The American Society of Health-System Pharmacists*. Retrieved 3 April 2011. <<http://www.drugs.com/monograph/prednisone.html>>
- [2] Asthma Action Plan (AAP), National Institutes of Health, 2007. [Online]. Available: https://www.nhlbi.nih.gov/files/docs/public/lung/asthma_actplan.pdf. [Accessed: 25 Jan 2016]
- [3] K. Chun, J. Webster, I. Santos and S. Mathur, "Real-time measurement of ventilation and respiratory sound for continuous monitoring of asthma control".
- [4] Krishnan, J. A., Lemanske, R. F., Canino, G. J., Elward, K. S., Kattan, M., Matsui, E. C., ... & Minnicozzi, M. (2012). Asthma outcomes: symptoms. *Journal of Allergy and Clinical Immunology*, 129(3), S124-S135.
- [5] R. Hopp and M. Pasha, "A literature review of the evidence that a 12% improvement in FEV 1 is an appropriate cut-off for children", *Journal of Asthma*, pp. 1-6, 2016.
- [6] C. Harty, "Methacholine Challenge", University of Wisconsin School of Medicine and Public Health.