

Low-cost, Open-source Spirometer

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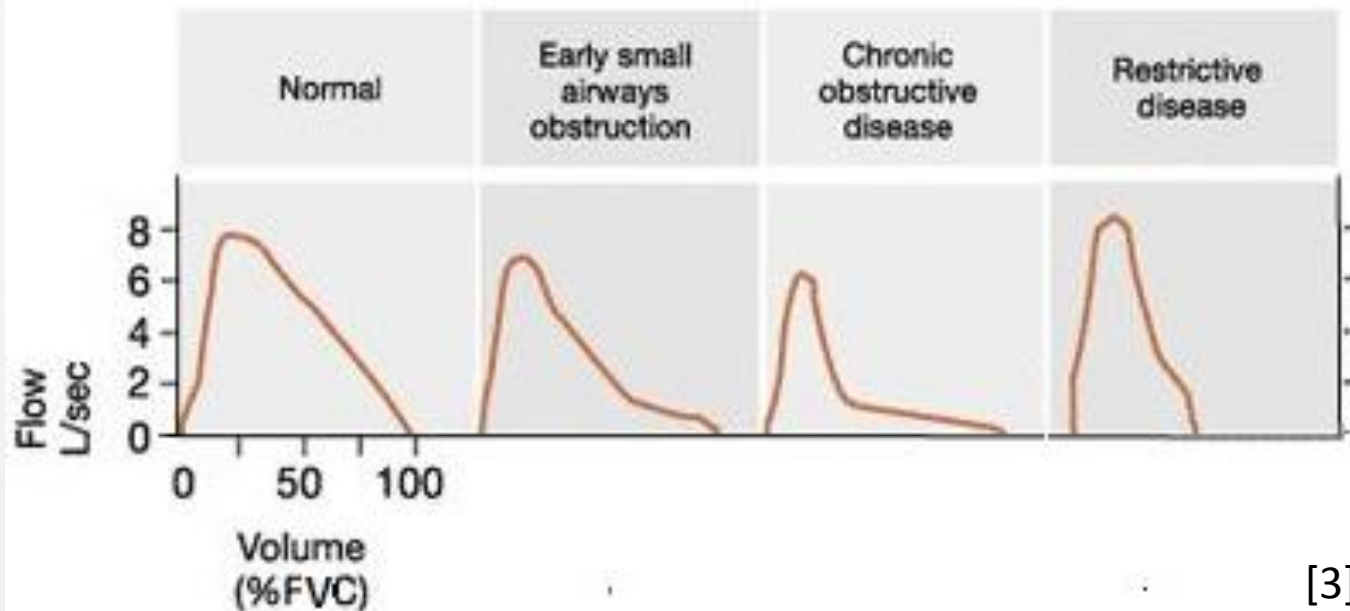
Chronic Respiratory Disease



- Asthma
 - Affects over 300 million people worldwide[1]
 - ~80% of fatalities in low income countries [2]
- Chronic Obstructive Pulmonary Disease
 - 4th leading cause of death worldwide
 - Estimated to be 3rd by 2020[3]

Spirometry Background

- Diagnose and monitor lung disease
 - Measures air flow and volume
- Test parameters
 - Peak Expiratory Flow
 - Fored Vital Capacity
 - Fored Expiratory Volume



Motivation

- Typical spirometer costs over \$1000
 - Beyond resources of emerging nation physicians
 - Many sufferers lack diagnosis and monitoring
- Technicians lack spirometry training
- High disease prevalence + lack of equipment = need for low-cost solution

Problem Statement

- Develop a low-cost, reliable spirometer
 - Affordable in developing nations
 - Standardized A/V coaching for patient
 - Connect to computer via USB
 - Evaluate quality of maneuver

Design Specifications

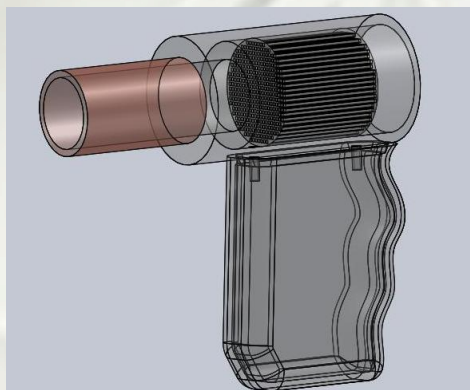


- Measure air volumes up to 8 L, flows to 14 L/s
- Durable and portable
- Calibrates using standard equipment
- Easy to disinfect
- Universal interface
- Cost under \$50

Block Diagram



- Forcefully Exhale



- Analog voltage output

[5]



[6]



- Amplification
- A/D conversion
- Output via USB

[7]



- Calculate test results
- Display spirogram

Graphical User Interface

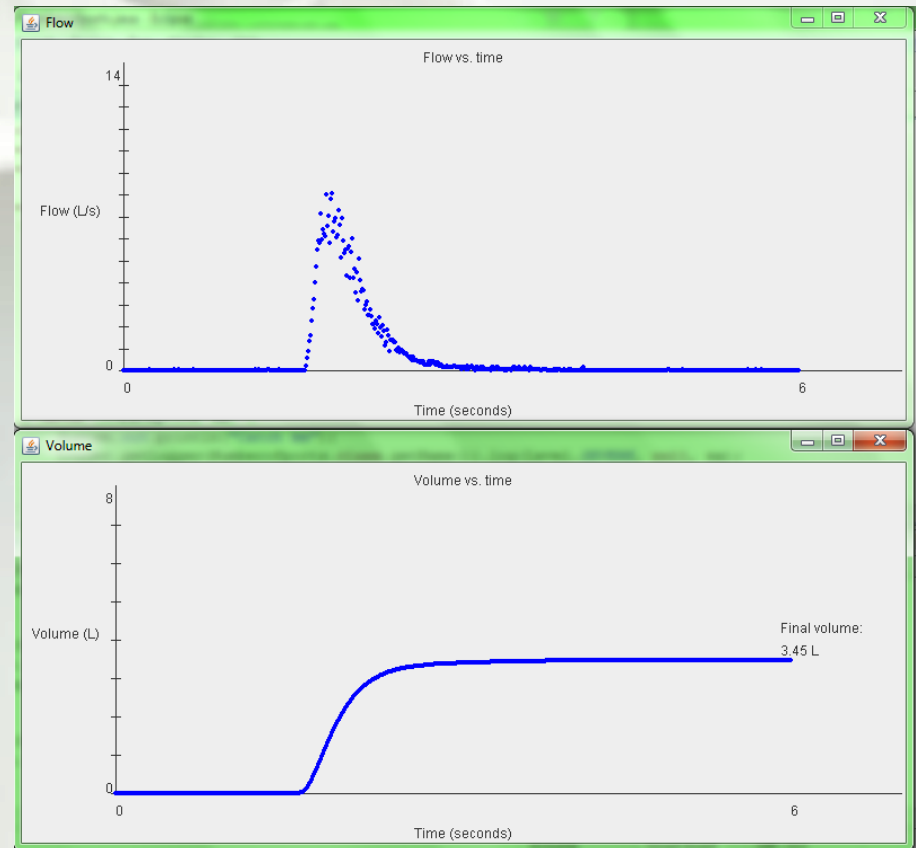


- Using Java
- Links to video tutorials
- Real-time
 - Flow/volume and volume/time graphs
 - Incentive animation to encourage user
- Major focus for this semester

Fall 2009 GUI

- Real-time graphing
 - Flow/time and volume/time graphs
- What was missing
 - Start/stop capabilities
 - Predictive parameters
 - Incentive animation to encourage user

Java display

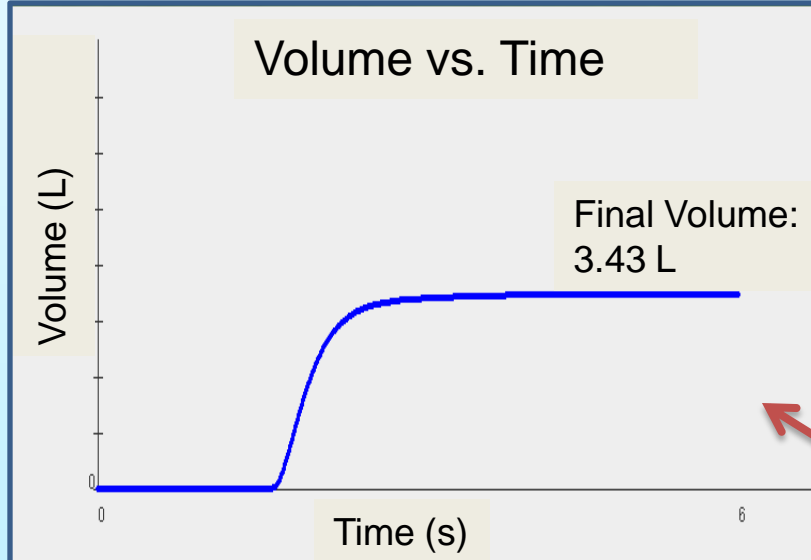


Spring 2010 GUI plan

Spirometer User Interface



Flow vs. time
Flow vs. volume
Volume vs. time
Edit patient
Animation



Predicted values

FVC: 3.15 L
FEV₁: 2.13 L
FEV₆: 0.11 L
PEF: 6.42 L/s
FEF_{25/75}: 3.04 L/s

Let user select what to display

Resizable Panels

Flow vs. time
Flow vs. volume
Volume vs. time
Edit patient
Animation



Select Animation ▾

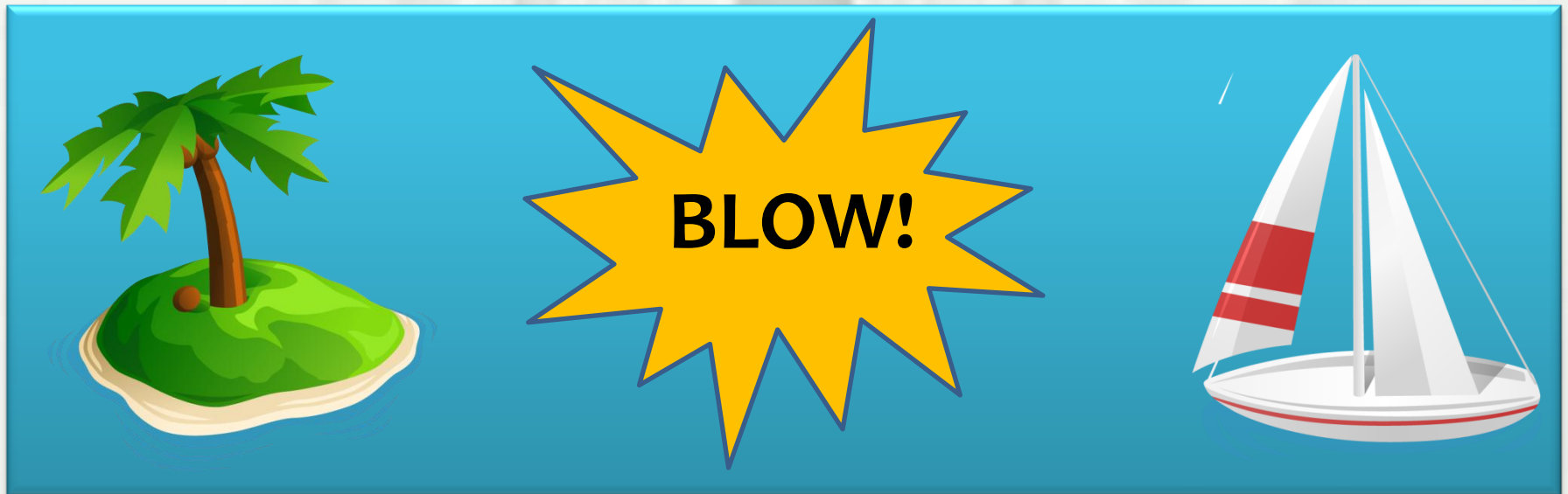
Start/Stop

Save

Menu

Incentive Animation

- Encourages maximal effort from user
- Exhalation must last at least 6 seconds
- Standardized experience



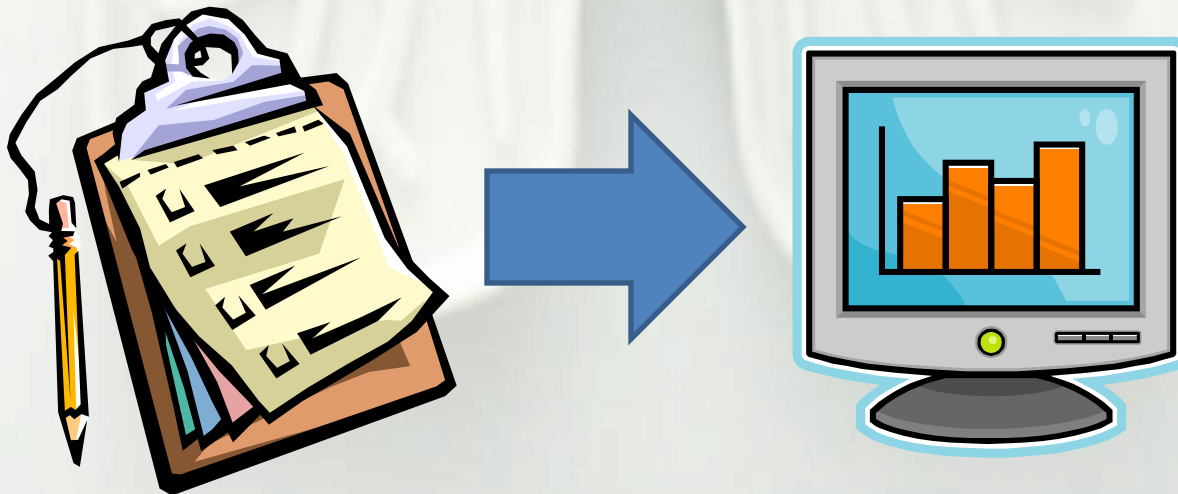
Validation and Calibration

- Sensor measures flow
 - Calibrate using volume
- Design Validation: Jones Syringe
 - Assess variance using linear correlation coefficient
- Technician Calibration: 3 L syringe



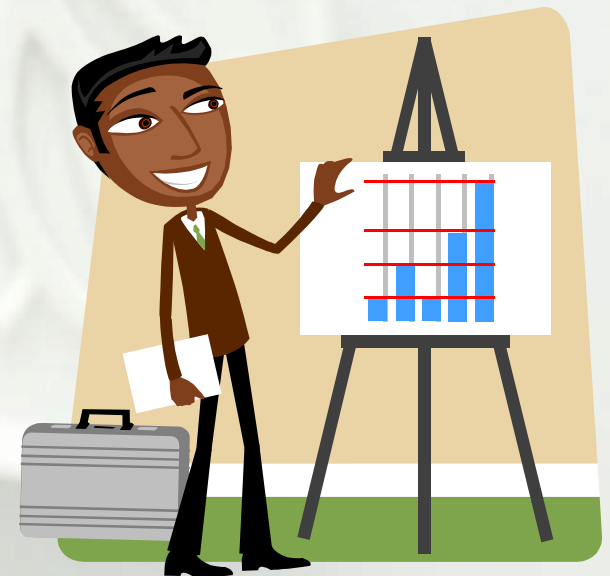
Clinical Validation

- Prototype used in a clinical setting
- Two spirometry technicians at different locations
- Evaluate experience with User and Technician surveys



Spring Goals

- Software and firmware programming
- Calibration – Within 3% of 3 L
- Documentation – IRB exemption for testing
- Clinical Validation
- Share results
 - Submission to respiratory science journal
 - Poster at ATS 2010 Conference in New Orleans



Questions/Comments?



References

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