Hemodynamic Analysis System

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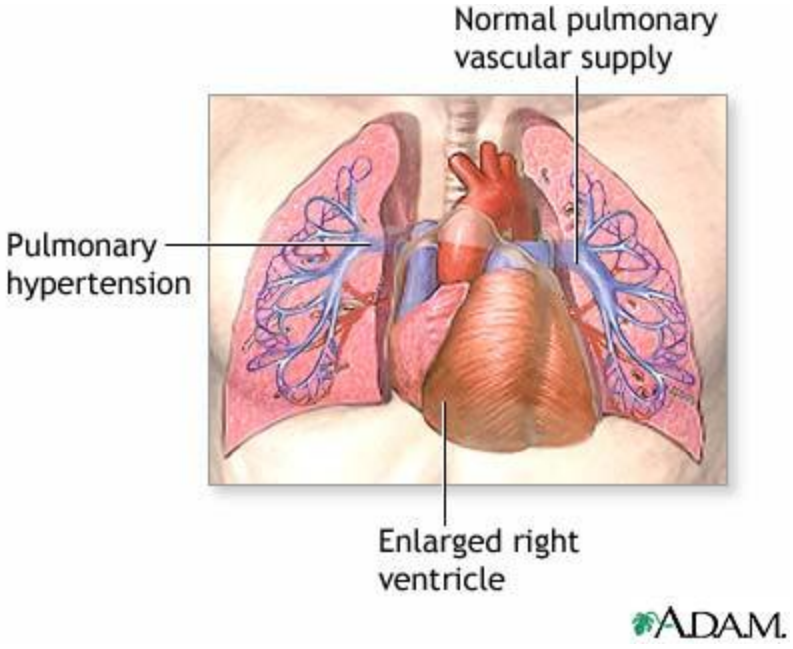
Overview

- Pulmonary Hypertension
- Echocardiography and Right Heart Catheterization
- Project Motivation
- Current Analysis System
- Specifications for New Device
- Device System Diagram
- Proposed Hemodynamic Analysis Designs
- Assessment of Designs
- Construction and Validation

Pulmonary Hypertension (PH)

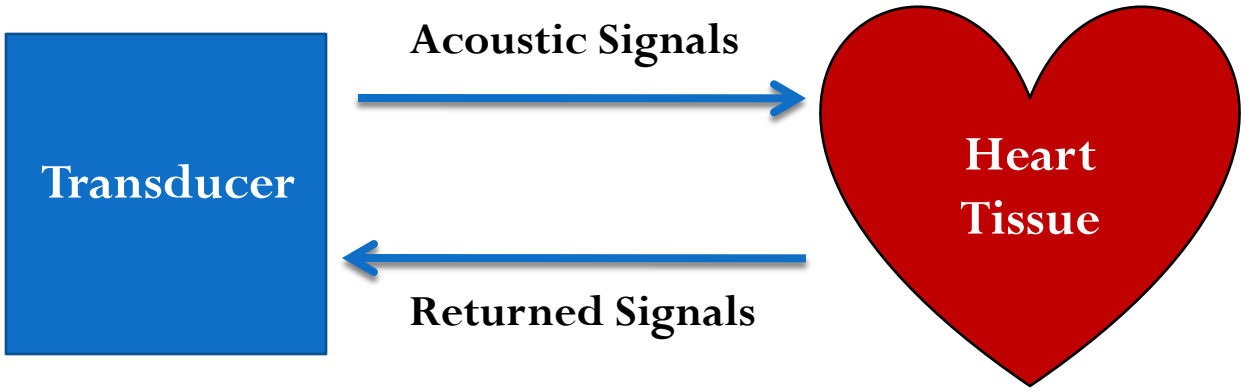
- High pressure in pulmonary arteries
- Heart cannot keep up with high pressures



- Can lead to a number of issues:
  - Enlargement of the right heart
  - Fluid build up in liver or other tissues
  - Heart failure

Doppler Echocardiography

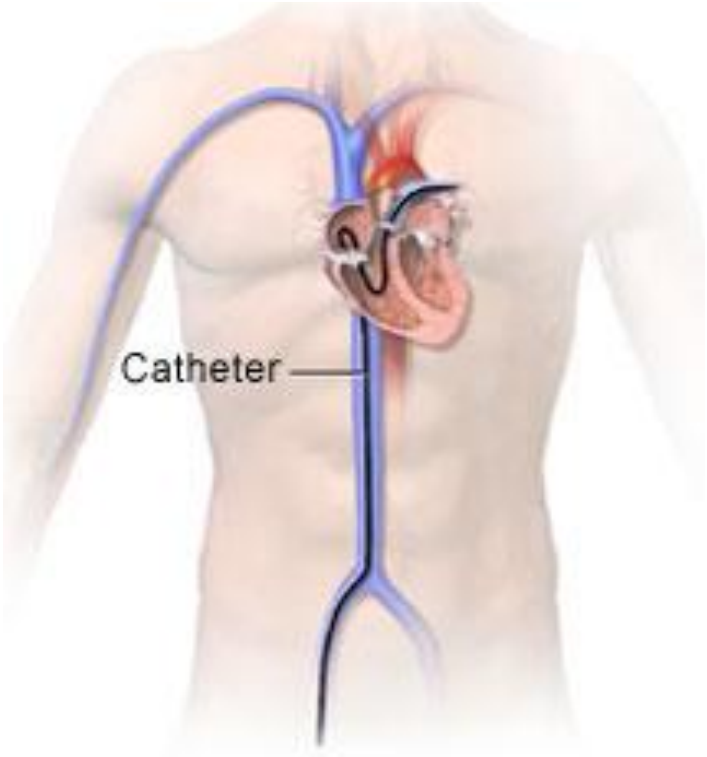
- Use of standard ultrasound to image the heart



- Returned signals are Doppler shifted
- The two frequencies are related by: $f_d = \frac{2 f_o v \cos\vartheta}{c}$
- Measures instantaneous velocity and flow rates

Right Heart Catheterization

- Measures pressure in the right heart and pulmonary arteries
- Catheter inserted into major vein and threaded to the pulmonary artery
- Used to monitor various heart conditions



Right Heart Catheter

Project Motivation

- Calculate pulmonary vascular impedance (PVZ) with Doppler echocardiography and right heart catheterization
- PVZ in diagnosing PH
  - Determines artery stiffness
  - Identifies defect location
- To calculate PVZ, must sync arterial flow & pressure
- Synchronizing device needed for earlier, more efficient detection of PH

Current Device

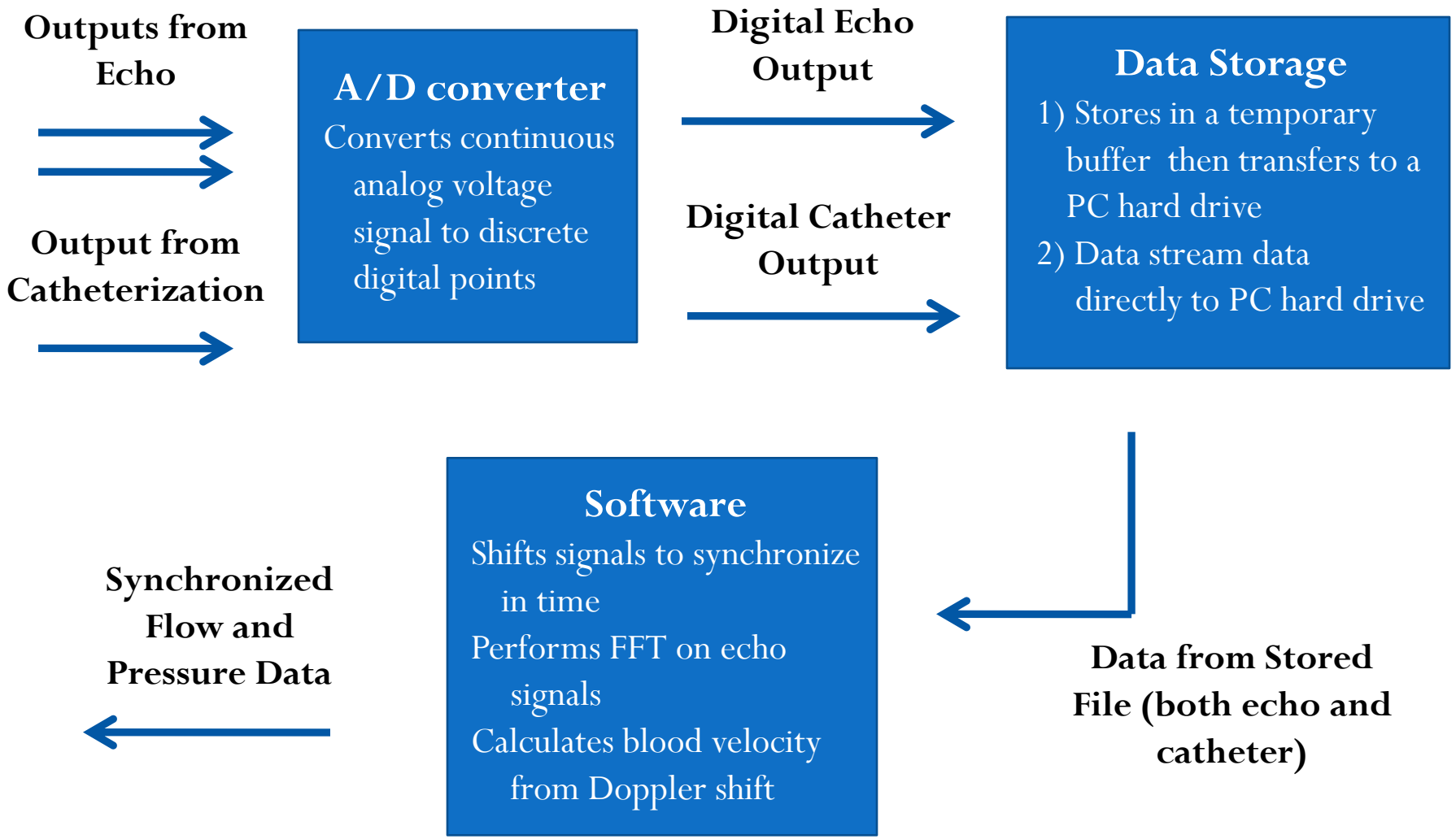
- Collects and analyzes right-heart catheterization, echo, and ECG data
- Raw data not synchronized
- Cannot calculate PVZ
- Provides excess data analysis
- Must be used in conjunction with large outdated PC
- Cost: $30,000

Front view of current device attached to outdated laptop

Design Specifications

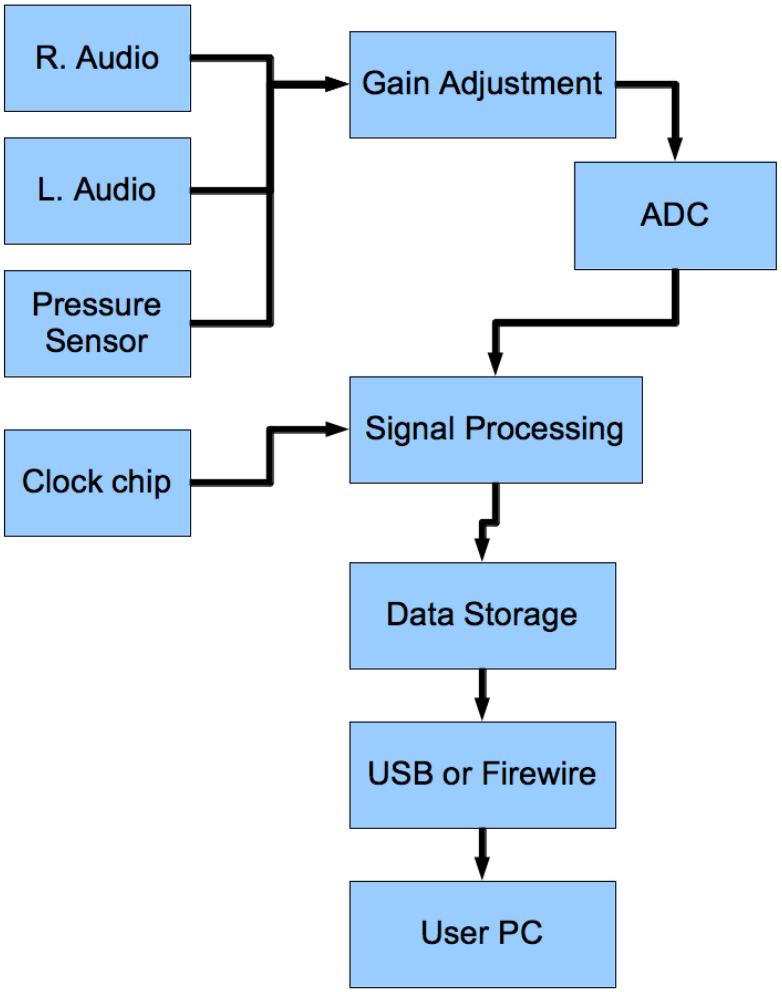
- Convert echo & catheter analog signals to digital output
- Synchronize time, pressure, and flow data
- Sample 20 times per cardiac cycle (50 Hz)
- Store data in a file for later interpretation
- Cost less than $1000/device
- Weigh less than 10 pounds, fit in a 12” cube
- Be aesthetically pleasing and professional

Conceptual System Diagram



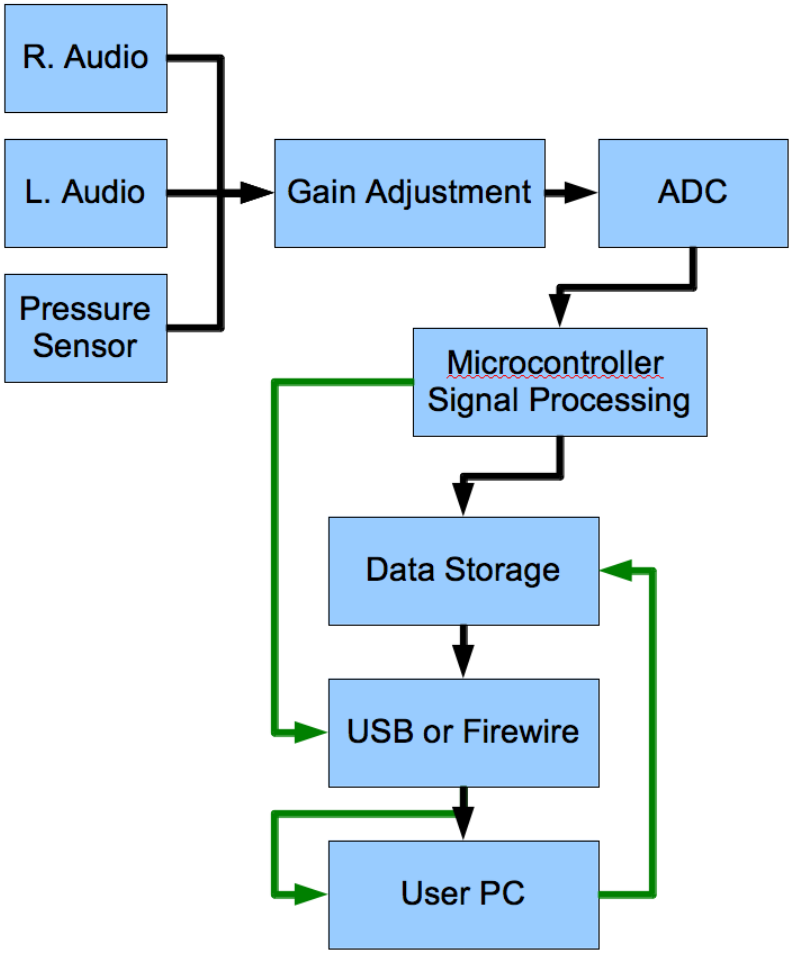
Design Alternative #1: Hardware Device

- ADC Data acquisition
- Hardware Signal Analysis
- Onboard Data storage
- USB or Firewire output
- Pros
  - Tailored to specific problem
  - Capable of synchronization
- Cons
  - Complicated hardware integration
  - Inadaptable



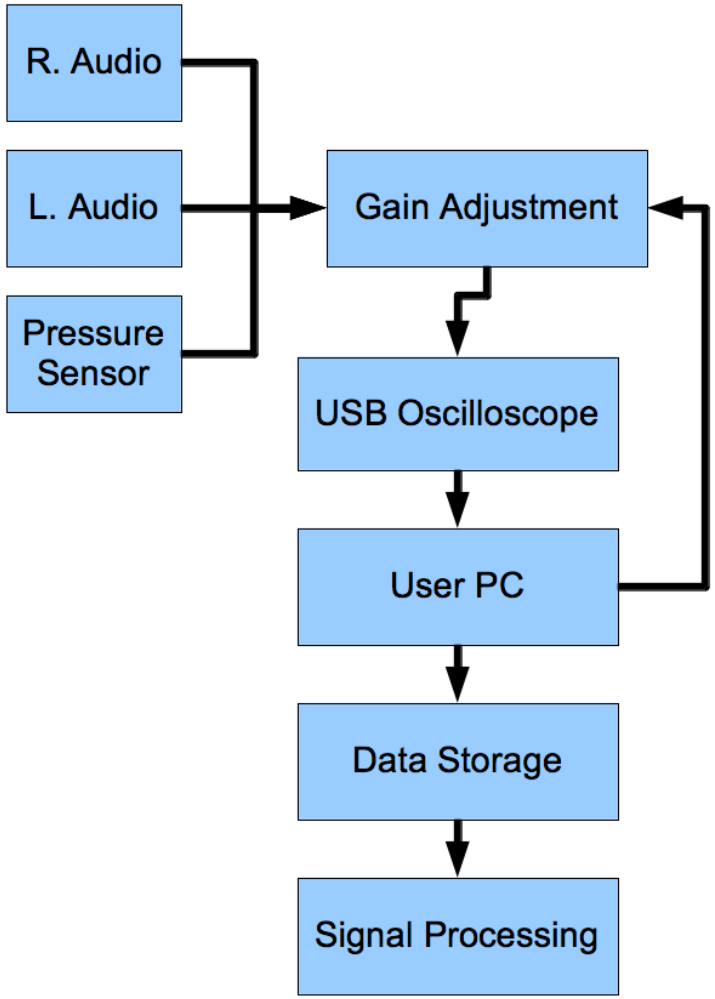
Design Alternative #2: Microcontroller

- ADC Data acquisition
- Microcontroller Signal Processing
- Onboard Data storage, or USB/Firewire PC interface
- Pros
  - Reprogrammable
  - Capable of synchronization
- Cons
  - Slow signal processing with JAVA
  - Input gain adjustments



Design Alternative #3: PC Oscilloscope

- USB ADC data capture
- Digital Oscilloscope
- Integrate with LabView for signal analysis
- Pros
  - Adaptable design
  - Simple data acquisition with high fidelity
  - Simple prototyping
- Cons
  - Expensive

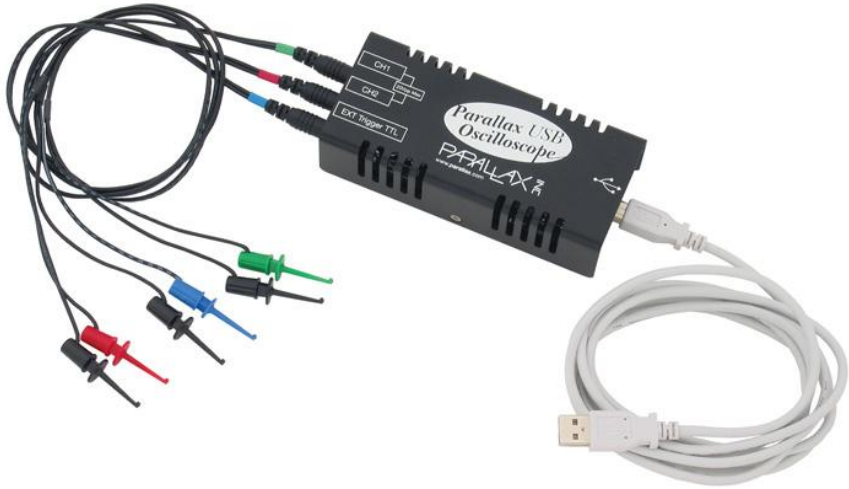


Design Matrix

Criteria	Weight	Microcontroller	Hardware Device	PC Oscilloscope
Cost	5	5	4	1
Ease of Production	15	9	5	13
Ability to Synchronize	20	15	15	20
Aesthetics	5	5	5	5
Sampling Frequency	20	20	20	20
User Friendly Interface	20	12	12	18
Size	5	5	5	5
Adaptability	10	5	2	10
Total	**100**	**76**	**68**	**92**

Selected Design

- 2 PC Oscilloscopes working together to offer 4 inputs
  - Parallax USB Model $139.95 each
  - 4th input can be used as a potentiometer to calibrate input gain
- Design Specs
  - 2 channels
  - 500 KHz sample rate
  - 200 KHz bandwidth
  - 8 bit vertical resolution



Prototype Testing

- Test synchronization of two oscilloscopes with a square wave
- Connect to both right heart catheter and echo machine
  - Schedule times for use
  - Both must be present
  - Human subject
- Test software/programming

Future Work

- Order necessary parts, build the device, and test it
- Gain experience using LabVIEW and/or MATLAB
- Software programming:
  - Create code to calculate blood flow velocity
  - Include diameter of artery
  - Synchronize oscilloscopes

Acknowledgments

- Professor Mitch Tyler
- Professor Naomi Chesler
- Professor Dennis Bahr
- Professor William Schrage

Questions

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- Figures
  - http://www.pphlaw.com/ (slide 3)
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