In the Matter of Certain Wearable Electronic Devices with ECG Functionality and Components Thereof

Investigation No. 337-TA-1266

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RDX-0003.1

Education

Dr. Collin Stultz

M.D., Ph.D

- **Harvard College**
  - Bachelor's degree in Mathematics and Philosophy
  - *magna cum laude*
- **Harvard Medical School**
  - Doctor of Medicine (Harvard-MIT Division of Health Sciences and Technology)
  - *magna cum laude*
- **Harvard University**
  - Ph.D. in Biophysics
- **Brigham & Women's Hospital**
  - Intern and Resident, Department of Medicine
- **Brigham & Women's Hospital**
  - Cardiology Fellow, Division of Cardiology

RX-309
RDX-0003.2

Practicing Cardiologist / Professor of Engineering MIT, Harvard

Dr. Collin Stultz

M.D., Ph.D

- Nearly 20 years as a board-certified cardiologist
  - Veteran's Affairs Hospital
    - 2003-2017 (~ 15 years)
  - Massachusetts General Hospital
    - 2017-present (~ 5 years)
- Nearly 20 years teaching undergraduate and graduate students
- Nina T. and Robert H. Rubin endowed Professor of Medical Engineering and Science and a Professor of Electrical Engineering and Computer Science
- Faculty member in Harvard-MIT Division of Health Sciences and Technology
- Previous work as Adjunct Associate Professor of Medicine, Boston University Medical School

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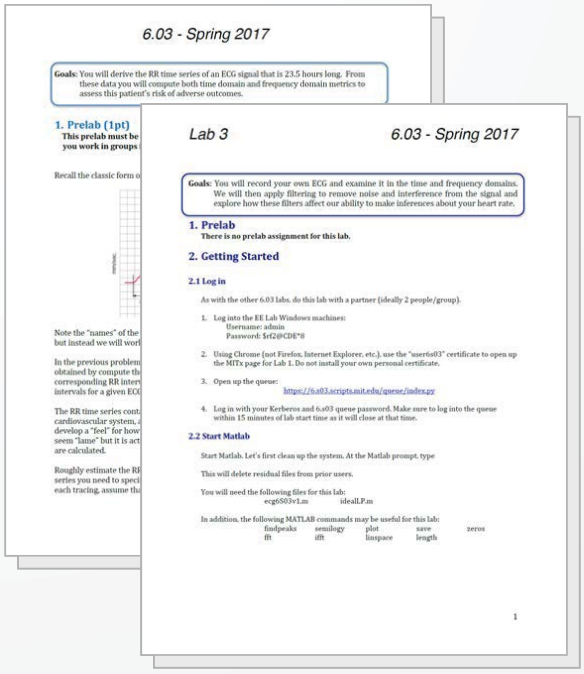
Teach Students How to Acquire ECG Data, Interpret Data



6.03 - Spring 2017

Goals: You will derive the RR time series of an ECG signal that is 23.5 hours long. From these data you will compute both time domain and frequency domain metrics to assess this patient's risk of adverse outcomes.

1. Prelab (1pt)
This prelab must be you work in groups

Recall the classic form o

Note the "names" of the but instead we will wor

In the previous problem obtained by compute th corresponding RR inter intervals for a given EC

The RR time series cont cardiovascular system, develop a "feel" for how seem "lame" but it is act are calculated.

Roughly estimate the RR series you need to speci each tracing, assume th

Lab 3 6.03 - Spring 2017

Goals: You will record your own ECG and examine it in the time and frequency domains. We will then apply filtering to remove noise and interference from the signal and explore how these filters affect our ability to make inferences about your heart rate.

1. Prelab
There is no prelab assignment for this lab.

2. Getting Started

2.1 Log in

As with the other 6.03 labs, do this lab with a partner (ideally 2 people/group).

1. Log into the EE Lab Windows machines:
   Username: admin
   Password: $rf2@CD$^8
2. Using Chrome (not Firefox, Internet Explorer, etc.), use the "user6o03" certificate to open up the MITx page for Lab 1. Do not install your own personal certificate.
3. Open up the queue:
   https://6.o03.scripts.mit.edu/queue/index.py
4. Log in with your Kerberos and 6.o03 queue password. Make sure to log into the queue within 15 minutes of lab start time as it will close at that time.

2.2 Start Matlab

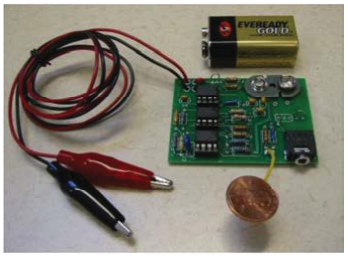
Start Matlab. Let's first clean up the system. At the Matlab prompt, type

This will delete residual files from prior users.

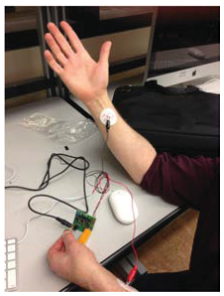
You will need the following files for this lab:
ecg6503v1.m ideall.P.m

In addition, the following MATLAB commands may be useful for this lab:
findpeaks semilogy plot save zeros
fft ifft linspace length

1



Electrocardiogram Circuit



4. Generate RR time series for two patients

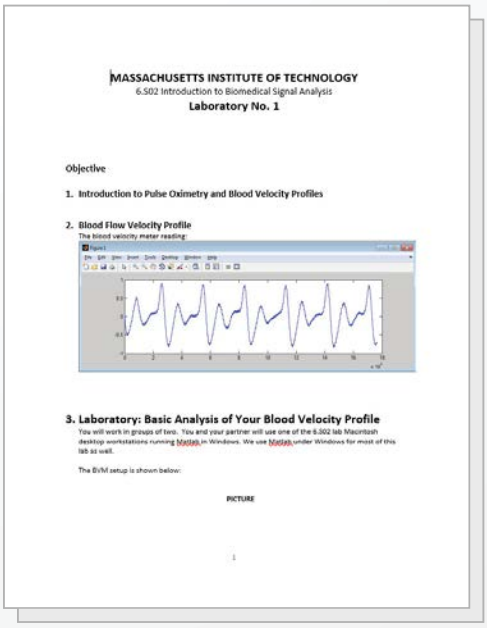
Several metrics have been developed to identify patients at high risk of death based on the RR time series. The first metrics were made to work on the time domain signals alone.

The basic idea is that no-one has an RR time series that is constant in time. Our heart rates naturally fluctuate throughout the course of a day. When we get excited our heart rate increases and when we go to sleep our heart rate slows down. The heart rate itself is controlled (in part) by the *sympathetic* and *parasympathetic* nervous systems. Stimulation of the sympathetic nervous system causes the heart rate to increase (i.e., the RR interval decreases) and parasympathetic stimulation causes the heart rate to decrease (i.e., the RR interval increases).

Therefore, over any given period of time, one would expect there to be some spread in the distribution of RR intervals.

RDX-0003.4

Teach Students How to Calculate HRV from PPG Signals



MASSACHUSETTS INSTITUTE OF TECHNOLOGY
6.502 Introduction to Biomedical Signal Analysis
Laboratory No. 1

Objective

1. Introduction to Pulse Oximetry and Blood Velocity Profiles

2. Blood Flow Velocity Profile
The blood velocity meter reading:

3. Laboratory: Basic Analysis of Your Blood Velocity Profile
You will work in groups of two. You and your partner will use one of the 6.302 lab Macintosh desktop workstations running Matlab in Windows. We use Matlab under Windows for most of this lab as well.

The BVM setup is shown below:

PICTURE

1

1. Introduction to Pulse Oximetry and Blood Velocity Profiles

Task 2:
Compute your average heart rate. To do this you will need to write a program that will allow you to identify the positions of the R waves. This is called segmentation. Feel free to use the built-in Matlab function "findpeaks".
Once you have the total number of beats, divide by the total time to get the average heart rate.

Task 3:
Now compute the instantaneous heart rate time series for your data.

Task 4:
Calculate the average instantaneous heart rate and use this to compute the average heart rate.

Task 5:
Record your BV for 30seconds, while you simultaneously hold your breath. (If you can't hold for 30s then just hold it for as long as you can.)
Make a plot of your heart rate as a function of time.

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