Fat Analysis of Meat with Smartphone Integration

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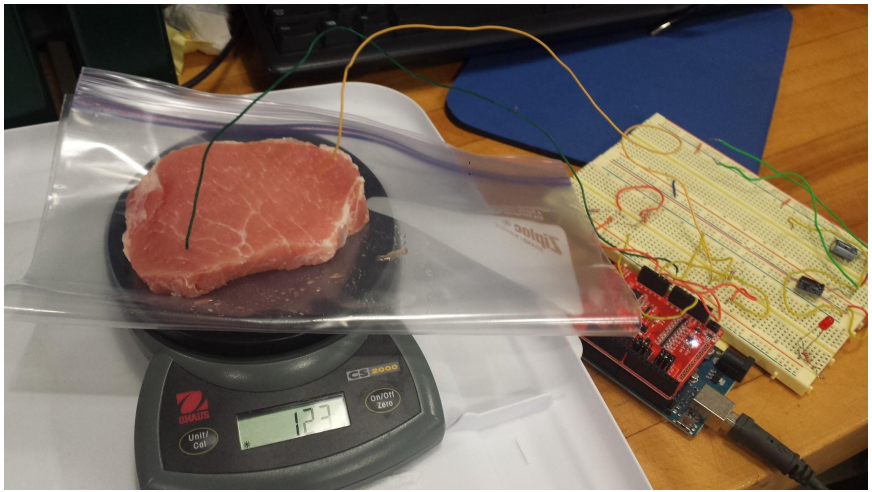
ECE 4012 L2A: Professor Bhatti

The FatAnalyzer

- Estimates the Fat % of Pork Chops
- Test lasts less than 10 seconds
- Android and iOS Support



Instructions

- Weigh the Pork
- Insert Probes into opposite ends of the meat
- Begin test on the FatAnalyzer app
- The results are displayed on the app

Hardware

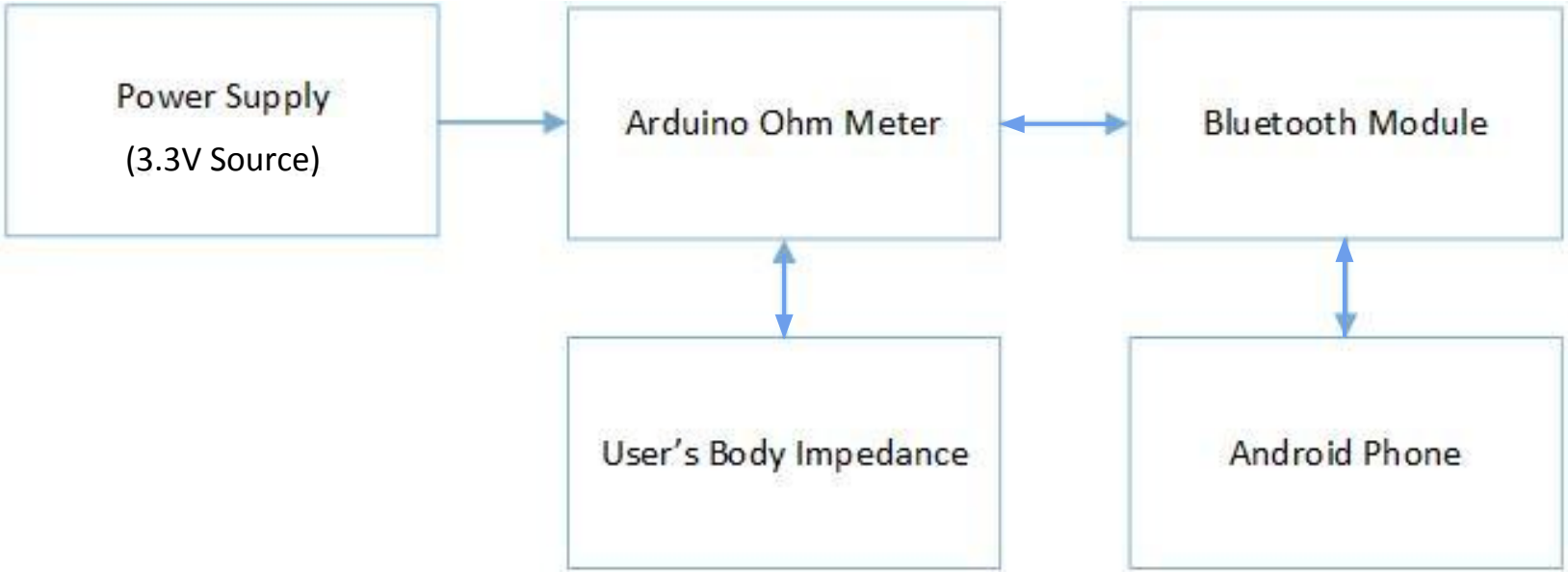
- Arduino Uno
- RedBearLab Bluetooth Low Energy Shield
- Simple set up with a 14.84 kOhm Resistor

- Other:
  - Smartphone with the FatAnalyzer app installed
  - Scale that measures in grams

Software

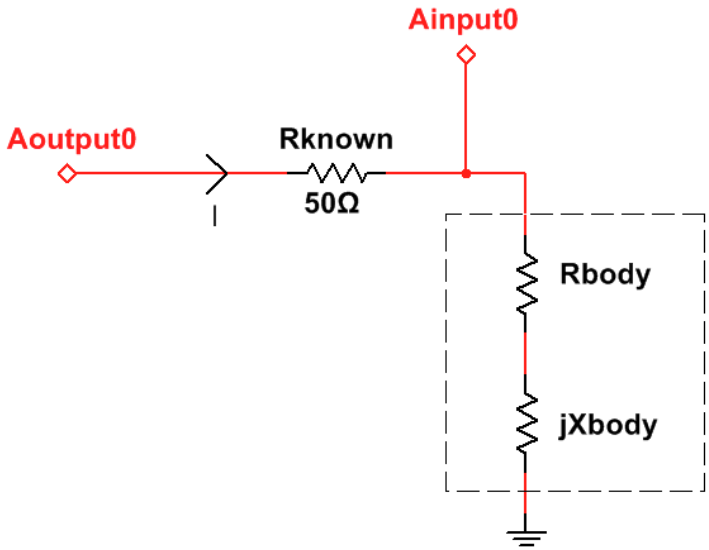
- Arduino uses short voltage pulses to test resistance of meat
  - Current is determined with the known resistance
- Plugs values for Resistance and Weight into the developed model
- Send Results to the Application via Bluetooth
- Smartphone Application

The System


Power Supply
(3.3V Source)
Arduino Ohm Meter
Bluetooth Module
User's Body Impedance
Android Phone

Arduino Ohm Meter

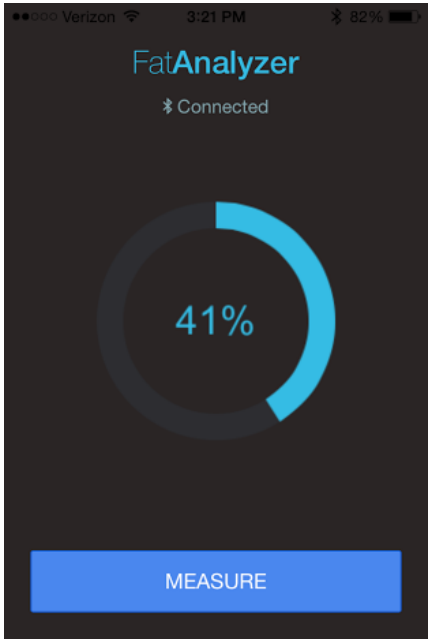
Input Voltage from Arduino Pin
Aoutput0

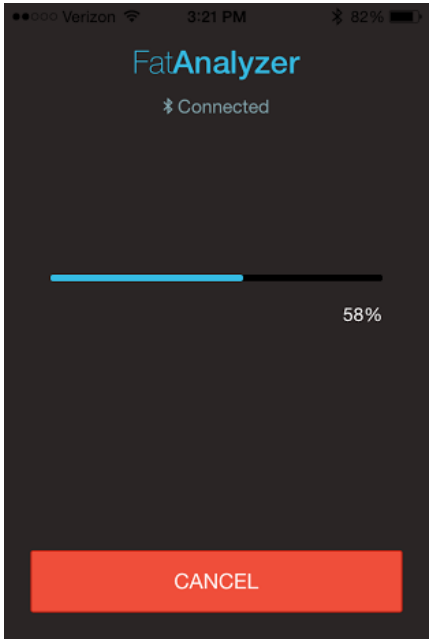


Bluetooth

- The Arduino is connected to RedBearLab's BLE shield
- Code is designed to actively ensure that the phone is connected to the FatAnalyzer
- Works on iOS and Android via Cordova (Write once, run everywhere!)

Mobile App Interface



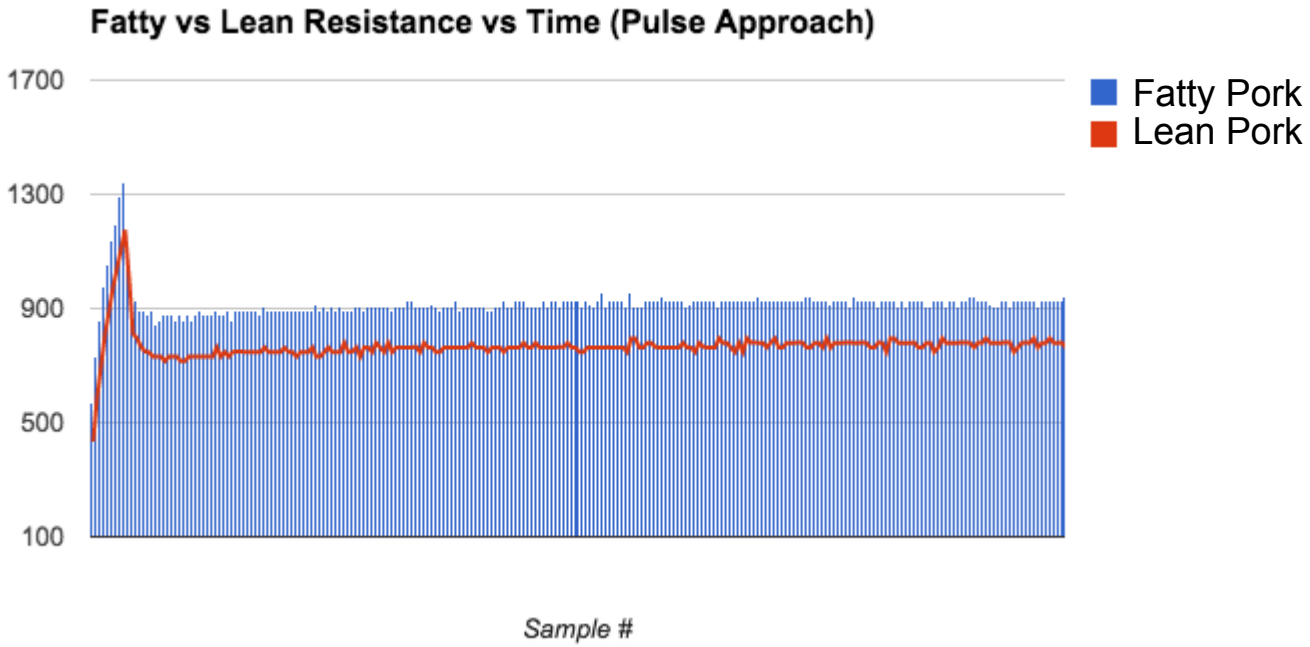


Biological Challenges

1. Meat begins to “charge up” slowly when a voltage is applied across it, causing the resistance reading to increase with time

2. Used a quick pulse approach to counteract this. The results are even more interesting..

Biological Discoveries



Generated Pork Regression Model

```
Linear regression                               Number of obs =      53
                                                F(  2,    50) =   67.27
                                                Prob > F      =  0.0000
                                                R-squared     =  0.8619
                                                Root MSE      =  5.2629

------------------------------------------------------------------------------
             |               Robust
  leanweight |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
resistanceohms |  -.0047503    .002185    -2.17   0.034     -.009139   -.0003616
       weightg |   .5542703   .0496811    11.16   0.000     .4544829    .6540577
         _cons |   1.207298   5.077608     0.24   0.813    -8.991377    11.40597
------------------------------------------------------------------------------
```

Fat Computation

1. Take computed lean weight from regression
2. Assume 35% water weight
3. Fat weight = Total Weight - Lean Weight - Water Weight
4. Fat percentage = Fat weight/(Non-water weight)

Testing

- Meat resistance was tested using the FatAnalyzer
- That data was collected along with the weight and length of the pork
- The Pork was then boiled down until fat and lean mass were separated and all water weight was removed

Specifications

Specification	Objective	Final Implementation
Target Subject	Cuts of Meat	Pork Chops
Meat Fat % Accuracy	10-20%	14%
Test Duration	<10 Seconds	<10 Seconds
Device Weight	<3 lbs	0.60 lbs
Signal Voltage	3.3 - 5 V	5 V
Number of Probes	2 - 4	2

Design Issues Encountered

- Original idea involved testing complex impedance of meat
  - Include capacitance as another parameter in the model
  - Through significant testing, it was found that complex impedance was a minimal factor
- Issues with Microcontroller selection
  - Started and ended with Arduino

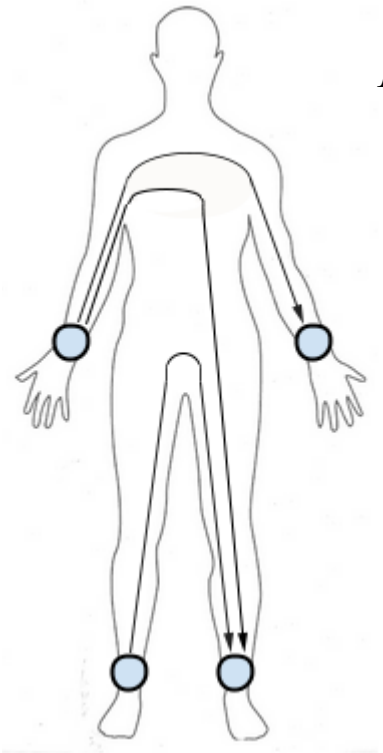
Design Issues Encountered

- Similarity between subjects
  - Because all subjects were prepared similarly within batches, there is very little variation between non-measured parameters within a sample group.
  - Breaks down when samples from different sources tested.
- Non-ideal testing methods
  - A more absolute fat-testing method was cost prohibitive.

Next Steps

- Increased testing for parameterization of more attributes of meat.
  - Allows for a more robust model over various metrics
- We feel this product could be much more widely applied
  - Chicken, beef, fish, etc.
- Human testing
  - Original Plan

Next Steps: Human Testing



$$FFM\ (kg) = 0.7 * (\mathbf{Ht^2}/\mathbf{R_{body}}) + .18 * \mathbf{BW} - .18 * \mathbf{Age} + .12 * \mathbf{X_{body}} - 2.5 \quad [1]$$

Ht^2 - Height of the subject squared

R_{body} - Real resistance of subject's body

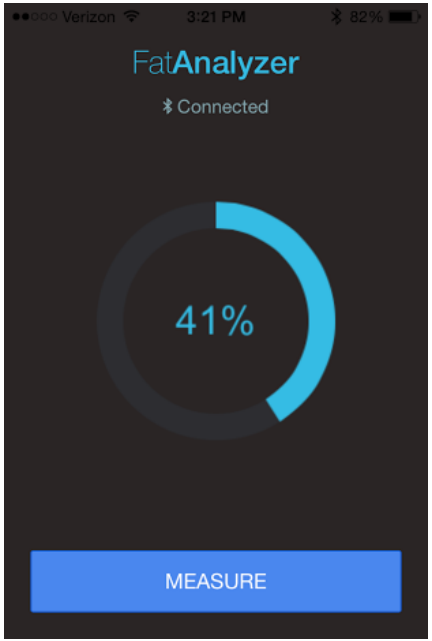
BW - Bodyweight of subject

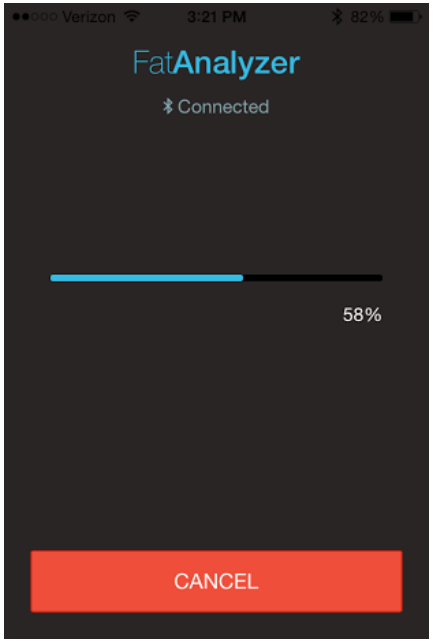
Age - Age of subject

X_{body} - Imaginary reactance of subject's body

Demonstration

Mobile App Interface





Arduino Ohm Meter

Input Voltage from Arduino Pin
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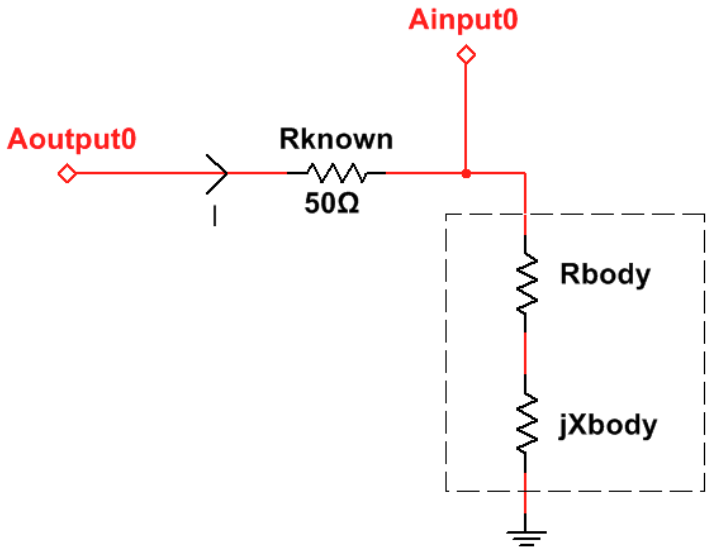

Conclusion

- We have a product that is fairly accurate
  - This is likely due to little variation between samples
  - Weight is the most significant variable
- As a proof of concept, this is a viable solution, but not a marketable product
  - Too many variables for such a small subject
  - Could be more viable with human subjects

Questions

References

[1] N. Macias. (2007, Aug. 15). *Body fat measurement by bioelectrical impedance and air displacement plethysmography: a cross-validation study to design bioelectrical impedance equations in Mexican adults* [Online]. Available: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2020472/#!po=3.12500

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